Woolgoolga to Ballina Pacific Highway upgrade

Threatened Frog Monitoring Annual Report 2018/19

Version 3.0

NSW GOVERNMENT

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……..
Ben Lewis
(B. Applied Science Hons)

…19th March 2020……

Date

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Ben Lewis (Lewis Ecological Surveys) – Field Surveys, Report Author and Report Review.

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Chris Thomson (Jacobs) – Project management and review.

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1.0 INTRODUCTION

1.1 Project Overview and Background to this Monitoring

The Woolgoolga to Ballina Pacific Highway Upgrade comprises approximately 155 km of highway to achieve a four-lane divided road extending north of Woolgoolga at the northern extent of Sapphire to Woolgoolga Upgrade to south of Ballina where it ties into the southern extent of the Ballina bypass. The project includes grade separated interchanges, service roads and upgrades to local road connections with construction being delivered in 11 sections.

The Threatened Frog Management Plan (RMS 2015) addresses the impacts of the upgrade and proposed mitigation on a number of threatened frog species including the Wallum Sedge Frog (*Litoria olongburensis*), Giant Barred Frog (*Mixophyes iteratus*) and Green-thighed Frog (*Litoria brevipalmata*). This management plan identifies both areas of known and potential habitat throughout the Project corridor and proposes a number of management actions to ensure the long-term survival of these species in the area of the project. In order to gauge the performance of these management actions, a pre-construction baseline monitoring survey was undertaken (Lewis 2014 a.b.c). The objective of these studies were to identify known threatened frog sites and to collect baseline data on the population and habitat condition. In summary, these studies along with some earlier construction monitoring have identified the following:

- The constructed carriageway bisects known Giant Barred Frog habitat at four locations and with this four reference sites have been selected;
- The constructed carriageway bisects numerous areas of known Green-thighed Frog habitat with 10 locations selected along with a further 10 paired reference sites for monitoring; and
- The constructed carriageway bisects five areas of known Wallum Sedge Frog habitat with a further five reference sites selected for monitoring.

2.0 STATUS OF THE MONITORING PROGRAMS

This report covers the following monitoring periods:

- Giant Barred Frog monitoring program performed during the operational phase in Year 4 for Sections 1 and 2;
- Wallum Sedge Frog monitoring program in Year 2 of the construction phase in Sections 8, 9 and 10; and
- Green-thighed Frog monitoring program schedule for Year 4 performed during the operational phase for Sections 1 and 2 but only Year 3 of the construction phase in Sections 3, 6 and 7.

3.0 GIANT BARRED FROG – *MIXOPHYES ITERATUS*

3.1 Species Profile

3.1.1 Description of the Subject Species

The Giant Barred Frog (*Mixophyes iteratus*) is a large, dark-olive green to black coloured frog that grows to 115 mm. It has a pointed snout and a broad lateral band of dark spots dividing the dark dorsal surface from the white or pale yellow, ventral surface (underside). The limbs have dark crossbars. The hind side of the thighs are black with large yellow spots. Two joints of the fourth toe are free of web (Cogger 2000). The skin is finely granular above but smooth below. The call of the male Giant Barred Frog is a deep guttural grunt (OEH 2014).

Plate 3-1. Giant Barred Frog (ad) from Corindi Creek**.**

Giant Barred Frog tadpoles are large and grow to over 100 mm in length. They are deep-bodied and ovoid, with a tail length twice that of the body. The tadpole's eyes are dorsolateral. The tadpoles are coloured yellow-brown above with dark spots and a dark patch at the base of tail. The underside is silver-white. The intestinal mass is obscured but the heart and lungs are visible from below (except near metamorphosis). The tail is thick and muscular (Anstis 2002). Fins are low and opaque with dark flecking (except the anterior half of the ventral fin; Meyer *et al.* 2001).

3.1.2 Distribution

The species is currently known from mid to low altitudes below 610 m above sea level (Hines *et al.* 2004), along the Coast and ranges from south-eastern Queensland to the Hawkesbury River in NSW. North-eastern NSW, particularly the Coffs Harbour-Dorrigo area, is now a stronghold whilst it appears to have disappeared south of the Hawkesbury and there are no recent records from the Blue Mountains (Hines and SEQTFRT 2002; DoE 2014).

3.1.3 Habitat and Ecology

Giant Barred Frog tends to forage and live amongst deep, damp leaf litter in rainforests, moist eucalypt forest and nearby dry eucalypt forest, at elevations below 1000 m (DoE 2014). Whilst it has been observed to prefer a closed forest canopy with a relatively light cover of vegetation at ground level (Aland and Wood 2013), they have been found in cleared or disturbed areas, for example agricultural landscapes with vegetated riparian strips and regenerated logged areas (Ingram

and McDonald 1993; Hero and Shoo n.d., cited in Hines *et al.* 2004; Lemckert and Brassil 2000; Lewis and Rohweder 2005). Giant Barred Frog are known from the lower reaches of streams which have been affected by major disturbances such as clearing, timber harvesting and urban development in their headwaters (Hines *et al.* 1999).

Giant Barred Frogs breed around shallow, flowing rocky streams and deeper slow moving rivers from late spring to summer. Females lay eggs onto moist creek banks or rocks above water level, from where tadpoles drop into the water when hatched (DoE 2014). Tadpoles grow to a length in excess of 100 mm and take up to 14 months before changing into frogs. They feed primarily on large insects and spiders, but have been known to consume small mammals (G. Madini pers. comm).

3.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Species Management Plan (RMS 2015). The exception was Site 2 where the transects were extended a further 500 m to 1 km in length at Dirty Creek (impact) and Pigeon Gully (control) following the recommendation from Year 3 sampling (Lewis 2018). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

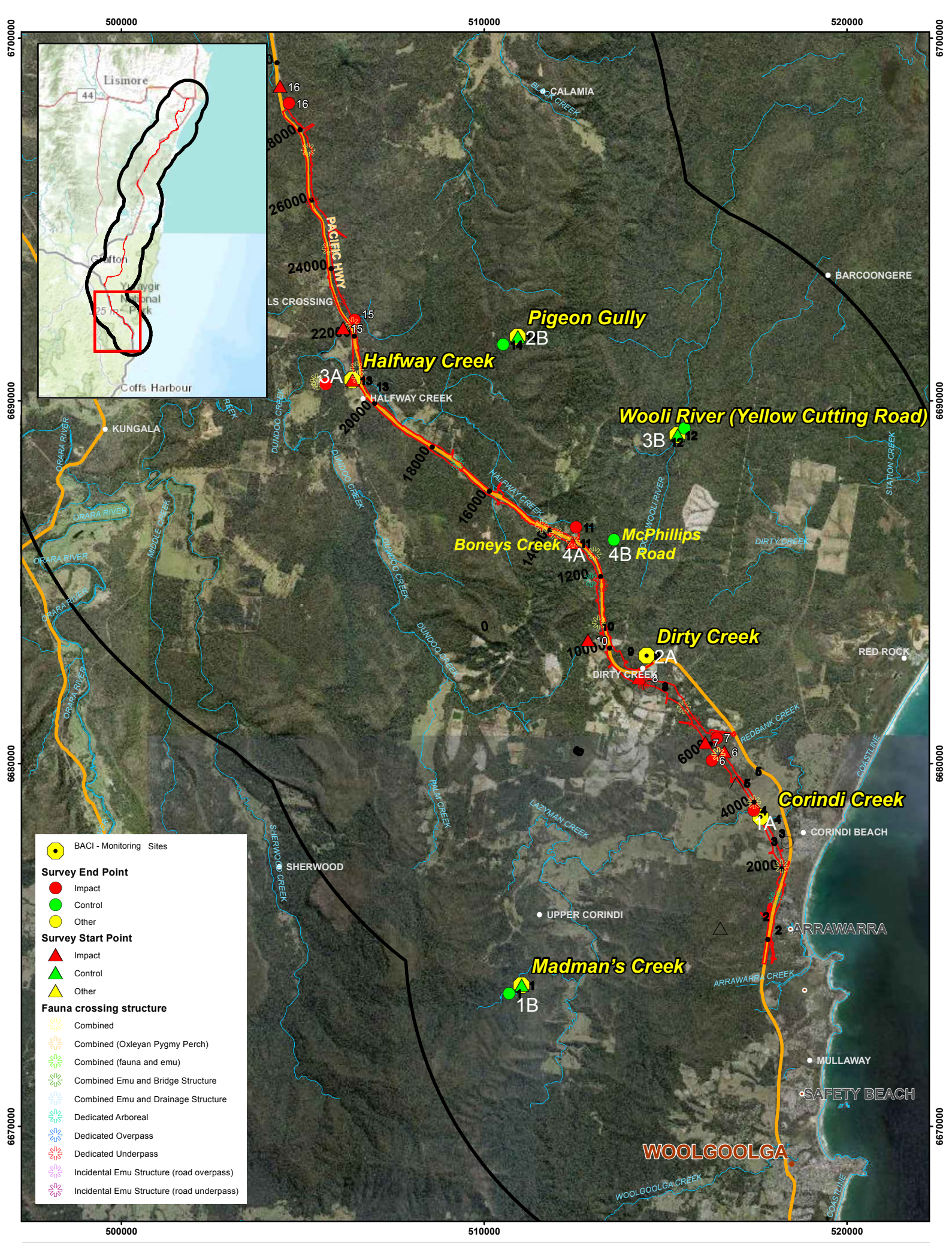
3.2.1 Site Selection and Treatment Design

All four sampling sites known as Site 1A, 1B, 2A, 2B, 3A, 3B, 4A and 4B occur within Sections 1 and 2 (Figure 2-1). Sampling accords with the BACI (Before-After-Control-Impact) approach which consists of the following:

- Impact sites which are identified in this instance with an ‘A” and may be potentially impacted by construction works or once the newly constructed carriageway is completed. Potential impacts may include but are not necessarily limited to habitat removal, a reduction in habitat connectivity, increased road strike, facilitating the distribution and increasing densities of exotic predators;
- Reference or control sites which are identified in this instance with an ‘B” and possess similar geographic landscape and habitat traits as the impact sites, but are located a sufficient distance (>200 m) and ideally upstream of the Upgrade. If this was not possible, a nearby sub catchment with similar attributes was also considered sufficient.

3.2.2 Timing of Surveys

Frog surveys were performed in a manner that was consistent with the Threatened Frog Management Plan (RMS 2015). Sampling occurred during late spring and again in late summer and into autumn when there had been 10 mm of rainfall in 24 hours over the past 7 days and ambient air temperature was close to or ideally exceeding 18^{o}C. Sampling between surveys was extended to 50 days to improve on temporal independence between the first and second survey (Table A1).



LEWIS ECOLOGICAL

Source:	Aerial Photo: © Land and Property Information (a division of the Department of Finance and Services) 2012 Giant Barred Frog Monitoring Sites: Lewis Ecological 2014 Project Boundary & Chainages: RMS 2013
Disclaimer:	This plan is based on or contains data provided by others. GeoView gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
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N W E S

0 990 1,980 2,970 3,960

Meters

A4 Scale 1:125,000

Coordinate System: MGA56 Projection: Transverse Mercator

Project Boundary
10km Project Buffer
Arterial Road
Watercourse

Giant Barred Frog *(Mixophyes iteratus)* Monitoring Sites

3.2.3 Frog Surveys

Frog surveys were performed in the manner outlined in the Threatened Frog Management Plan (RMS 2015). This involved:

- 500 m transect with 250 m either side of the Project corridor with the start and finish extent recorded using a hand held GPS in GDA94. At Site 2, this was extended to 1 km following an absence of frogs on the existing 500 m transect;
- Field surveys comprised spotlighting and call broadcast during the nocturnal transect;
- For each frog, the following information was collected:
    - Distance from the stream edge measured to the nearest 0.1 m;
    - Position within the microhabitat (i.e. under litter, above litter, exposed, on rock/log);
    - Sex (male, female, unknown) based on size of frog and inspection of nuptial pads present in male frogs;
    - Age class (adult = >60 mm; sub adult = 40-60 mm; juvenile = <40 mm)
    - Snout-vent length (mm);
    - Weight (grams); and
    - Breeding condition with:
        - males assessed on the colouration of their nuptial pads (i.e. no colour, light, moderate, dark) in accordance with a classification developed by Lewis Ecological Surveys (Table 2-1);
        - females based on whether they were gravid (i.e. typically adult weighing > 100 grams) or not gravid (egg bearing);
        - frogs with a snout vent length of <60 mm were classified as immature.
    - Microchipped with Trovan™ nano transponders to individually mark frogs.

All handling procedures were undertaken in accordance with the *Hygiene Protocols for the Control of Disease in Frogs* (DECW 2008) and NSW Animal Care and Ethics Approval (Trim14/3786).

3.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky taken at the start and finish of the survey and averaged;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).

3.2.5 Monitoring of Connectivity Structures

Three connectivity structures were identified for monitoring and include the following:

- Bridge over Corindi Creek (62 m) at ch. 3600;
- Culvert at Boneys Creek (3 x 3 m; 100m) at ch.13310, and
- Bridge over Halfway Creek (57 m) at h. 20780.

No connectivity structure was identified for monitoring at Dirty Creek as the population and suitable habitat is restricted to the downstream side of the carriageway.

Sampling for frogs was performed in the same manner as described above. The use of PIT tags enables the location of the frog to be documented and approximately what distance upstream or downstream from the carriageway along with what side of the stream bank it was captured on. Demonstrated use of the structure has been defined as documented evidence that a recaptured frog has moved beneath the carriageway.

3.2.6 Monitoring of Riparian Revegetation

Riparian revegetation monitoring was performed where planting beds were located within 30 m of the water course at Corindi Creek, Boneys Creek and Halfway Creek. Planting beds were not considered if they occurred on the carriageway side of the permanent frog fence. At each of the planting beds, the proportion of failed plantings was estimated. This could be done due to the configuration or uniformity used at most of the planting beds. Total weed coverage was also estimated as a total percentage cover of the revegetation area. At this time, the rehabilitated stream bank was visually inspected for signs of instability and notes taken on the types of materials used. This information would then be used to assess the overall performance of the riparian rehabilitation program outlined in the Threatened Frog Management Plan.

3.3 Year 4 Monitoring Results

3.3.1 Frog Population

Giant Barred Frogs were recorded at 7 (88%) of the 8 sites including Site 1A (Corindi Creek), 1B (Madmans Creek), 2A (Dirty Creek), 3A (Halfway Creek), 3B (Yellow Cutting Road), 4A (Boneys Creek) and 4B (McPhillips Road-Upper Halfway Creek; Figure 3-1). Frogs were not recorded from the reference Site 2B (Pigeon Gully; Table 3-1).

Sampling recorded 112 frogs with:

- Corindi Creek (Site 1A) - 27 frogs comprising 17 adults, seven sub adults and three juveniles. Eight of the frogs were recaptures from previous construction monitoring events and include the following:
    - Adult male (000735A0AF) that continues to use habitat around 20-60 m upstream from the carriageway with captures recorded in Year 2, 3 and 4.
    - Adult male (7357972) that has remained around 200 m upstream with captures in Years 2, 3 and 4.
    - Adult female (7356F45) that remains approximately 150 m upstream with captures in Years 2, 3 and 4.
    - **Adult female (735D21B) that has moved from approximately 80 m downstream in Year 3 to 70 m upstream in Year 4. For this 150 m movement to have occurred, the frog would have moved beneath the twin bridges and through the area of rehabilitated riparian habitat**.
- Madmans Creek (Site 1B) – 25 frogs comprising 10 adults, 11 sub adults and four juveniles. Two of the captures were from previous monitoring events performed in Year 3;
- Dirty Creek (Site 2A) – Four frogs comprising three adults and a sub adult. The 500 m extension of the transect yielded an additional three adult frogs. There were no recaptures from previous monitoring events.
- Pigeon Gully (Site 2B) - No frogs were recorded during Year 4. This includes the 500m extended area;
- Halfway Creek (Site 3A) – 36 frogs comprising 30 adults, four sub adults and two juvenile. Six of the captures were from previous monitoring events and include the following summary:
    - Adult female (735B8F8) from Year 3 has moved further upstream closer to the carriageway.
    - Adult male (735431F) from Year 2 remains upstream but has moved around 60 m closer to the carriageway.
    - Adult female (73582EC) from Year 2 has moved from just upstream outside of the construction zone to the revegetated area on the northern bank.
    - Adult male (7357C8D) from Year 2 has remained around the periphery of the downstream rehabilitated area.
    - Adult female (735B8F8) from Year 3 has remained in the same general area that received some powerline easement works during the course of the construction works.
    - Adult male (7359655) from Year 4 (early summer survey) has remained at the downstream edge of the rehabilitated area.

Four adult frogs were recorded using the revegetated riparian zone and comprised three adult females and one adult male with frogs found on both the north and south banks;

- Yellow Cutting Road (Site 3B) – 15 frogs with five of these adults, seven sub adults and two juveniles. There were no recaptures at this site. One tadpole was dip-netted from around 75 m downstream;
- Boney's Creek (Site 4A) – Two frogs, a young adult female and a sub adult from the autumn survey only. There were no recaptures at this site and no frogs were recorded on the upstream side of the carriageway (i.e. the top half of the transect); and
- McPhillips Road (Site 4B) – Three frogs comprising two young adult females and a sub adult frog. There were no recaptures.

In accordance with recommendations outlined in the baseline surveys, captured frogs were microchipped for individual verification during later sampling and to assist in the connectivity structure monitoring. Seventy-eight (78) frogs were micro-chipped, whilst the remainder were either recaptures, had simply eluded capture or were too small (<40 mm snout-vent) to insert microchips.

3.3.2 Connectivity Structure & Permanent Frog Fence Monitoring

Corindi Creek (Site 1A) - Eight frogs were recaptures from previous construction monitoring events. One of these, an adult female (735D21B) had moved from approximately 80 m downstream in Year 3 to 70 m upstream in Year 4. For this to have occurred, the frog would have moved beneath the twin bridges and through the area of rehabilitated riparian habitat. The remaining seven recaptures still reside on the same side of the carriageway.

Surveys of the permanent frog fence found no Giant Barred Frogs on the carriageway side of the fence. There were a number of potential breach points for frogs to move up onto the highway, namely no frog fence installed between the bridges, numerous gaps at the bottom of the frog fence along with the fence return installed the opposite way (Plate 3-2).

Plate 3-2. Missing frog exclusion fence at Corindi Creek on the northern abutment (left) and frog fence return facing the opposite way along with numerous holes at the bottom of the fence (right).

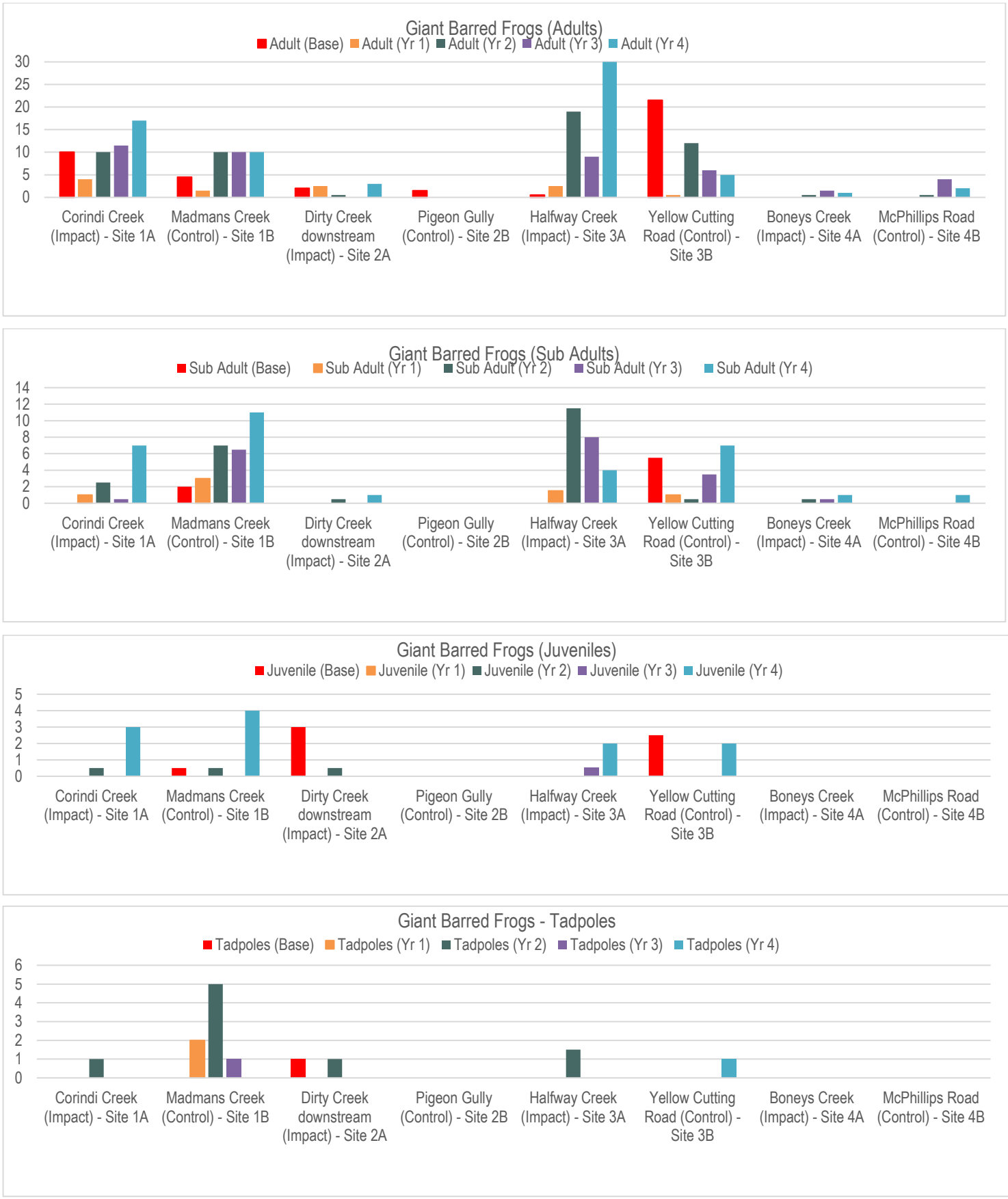


Figure 3-2. Giant Barred Frog abundance recorded during baseline and construction/operational monitoring Years 1-4 according to age class.

Table 3-1. Summary of the Giant Barred Frog Year 4 surveys for BACI Sites 1-4. Numbers in parentheses represent mean baseline abundance.

	Year 4 (Surveys)					
BACI Site	**Date**	**Total Number Frogs Captured**	**Calculated Mean No. of Frogs Per 500 m**	**Frog Management Mitigation Observed or Recorded**	**General Comments**	**Presence of Giant Barred Frogs Confirmed in Baseline Survey**
1A ch.3600 (Corindi Creek)	4th December 2018 23rd April 2019	27	13.5 (10)	i. Permanent frog fence installed, however, number of potential breach points/defects. ii. Bridges installed to maintain habitat connectivity. iii. Revegetation and bank stabilisation works observed. iv. No frogs captured from within the rehabilitated works area. v. Numbers of frogs recorded is higher than the baseline surveys.	i. Demonstrated habitat connectivity restored with adult female (735D21B) moving from 80 m downstream in Year 3 to 70 m upstream in Year 4. ii. Frogs recorded both upstream and downstream of the Upgrade. iii. Frog fence contains a number of breach points. Only likely to present a problem during flood flows that manage to breach the banks of the main channel as frogs would be pushed away from their normal occupation areas which as the data shows is <10 m from water's edge.	Yes
1B (Madmans Creek)	5th December 2018 23rd April 2019	25	12.5 (7)	Outside works footprint.	i. Frog counts are markedly higher than the baseline surveys which had been performed during largely dry seasonal conditions. ii. Site periodically retracts to a series of pools, and with this marked variability in count data is expected.	Yes
2A ch. 8500 (Dirty Creek)	27th February 2019 23rd April 2019	4	2 (5)	i. Rehabilitation upstream observed. ii. Frogs rediscovered along the existing monitoring transect. iii. Increase transect length (Year 3 recommendation) yielded additional frogs.	i. Habitat connectivity less of a concern as Project bisects edge of known habitat and may not isolate it.	Yes
2B (Pigeon Gully)	27th February 2019 23rd April 2019	0	0 (1.5)	Outside works footprint.	i. Ongoing absence at site during Year 4 monitoring.	Yes
3A ch.20800 (Halfway Creek)	6th December 2018 26th April 2019	36	18 (0.5)	i. Frogs recorded within the rehabilitated zones. ii. Permanent frog fencing remains intact. iii. No frogs recorded on the road side of the permanent frog fence. iv. Frogs recorded on both sides of the carriageway.	i. Frog fence contains a number of breach points around the stone abutments. Only likely to present a problem on south bound lanes.	Yes
3B (Yellow Crossing Road)	5th December 2018 26th April 2019	15	7.5 (29.5)	Outside works footprint.	i. Far fewer frogs than recorded during the baseline survey.	Yes
4A ch.13300 (Boneys Creek)	6th December 2018 24th April 2019	2	1 (0)	i. Permanent frog fencing observed. ii. Two cell box culvert provides connectivity for tadpoles.	i. No frogs recorded on upstream side to date and not previously mapped as known habitat.	No
4B (McPhillips Road)	6th December 2018 24th April 2019	3	1.5 (0)	Outside works footprint.	i. Far more frogs recorded along this transect than previous monitoring events and this mirrors the nearby impact site (Boneys Creek).	No

Halfway Creek (Site 3A) – Six of the captures were from previous monitoring events and there was no evidence to suggest any of these have crossed beneath the bridge. Five frogs have been recorded using the rehabilitated areas and this includes both the northern and southern banks on both the upstream and downstream sides of the bridge (Plate 3-3).

No barred frogs were found along the carriageway side of the permanent frog fence. During these inspections, some of the installed frog fence is not consistent with the designs and was found to contain a large gauge mesh size that would only prevent larger barred frogs from accessing the carriageway, or trapping frogs as they attempt to move through it (Plate 3-4).

Plate 3-3. Adult male frog using the southern bank rehabilitated area and female using the northern bank planting bed**.**

Plate 3-4. North bound fence on the Halfway Creek bridge abutment showing large aperture wire not suitable as frog fence.

Boney's Creek (Site 4A) – No recaptures were recorded at this site during Year 4 and all eight previously PIT tagged frogs were captured on the downstream side of the carriageway. No Giant Barred Frogs were found on the carriageway side of the fence as part of permanent frog fence surveys. There are however, a number of potential breach points where the bottom of the fence should connect with the natural or reinstated ground (Plate 3-5).

Plate 3-5. Example of permanent frog fence at Boneys Creek that hasn't been pinned to the reinstated ground.

3.3.3 Riparian Revegetation Monitoring

Riparian revegetation monitoring took place where plantings occur as part of the monitoring transect and integrate with habitat connectivity structures such as the bridges at Corindi Creek and Halfway Creek or the culvert at Boneys Creek. A summary for each site is provided below.

Corindi Creek - Planting failures were measured at 5% (Plate 3-6). Total weed coverage was measured at 8% and limited to the outer edges of planting beds. This is within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. Past bank erosion has been addressed on the southern stream bank with large stone pitching. On the northern downstream bank, tree stumps have been used. Both appear effective at reducing or eliminating erosion of this highly dispersive sandy loam in Year 4.

Plate 3-6. Planting beds upstream of the bridge on the upper stream bank (left) and along the streambank edge (right**).**

Halfway Creek (3A) - Planting failures were measured at 8% and were concentrated to those beds beneath the bridge spans that receive little or no natural rainfall (Plate 3-7). This is within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. Total weed coverage was measured at 12% and became more prevalent on the outer edges of the planting beds, particularly on the northern bank upstream of the south bound bridge (Plate 3-7). Here, most of the weeds are perennial grasses and annual herbaceous ground covers. There was no sign of current bank erosion with some large aggregate used as part of rehabilitating the southern bank.

Plate 3-7. Planting beds upstream of the bridge (left) versus planting beds beneath the bridge (right) with no rainfall.

Boneys Creek (4A) - Planting failures were measured at 10%. Total weed coverage was measured at 18% and became more prevalent on the outer edges of the planting beds. This is within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. There was no sign of current bank erosion with some large aggregate used to dissipate stream flows during flood events (Plate 3-8). Interestingly, most of the riparian zone consists of large

aggregate with only some localised planting beds or the use of frangible mixes whilst some bare earth or mulched areas with no tube stock planting has occurred in other riparian areas (Plate 3-9).

Plate 3-8. Planting beds upstream of the bridge (left) versus planting beds beneath the bridge (right) with no rainfall.

Plate 3-9. Riparian zone on upstream side at Boneys Creek with large aggregate to control erosion but no use of plantings on mulched creek bank.

3.4 Discussion

Monitoring during Year 4 revealed a number of differing trends with frogs appearing at some sites where they had remained absent in previous years whilst there was continued absences at Pigeon Gully (Site 2B). Most sites showed some form of recruitment into the population in the form of juveniles or sub adults. Below is a discussion for each of the four BACI sites.

Site 1 - Corindi Creek (Impact) and Madmans Creek (control)

The numbers of adult frogs at the impact site along Corindi Creek continues to exceed the pre construction baseline density of 10 frogs per 500 m of riparian habitat with a mean of 13.5 frogs per 500 m of riparian habitat. Importantly, more sub adult and juvenile frogs were recorded than previous monitoring events indicating some of the more prominent rainfall events over the past two seasons provided successful breeding at this location. Frogs remain distributed on both sides of the carriageway with a slight skew towards more frogs upstream which has always been the case.

The installed or operational mitigation at this site includes twin bridges, permanent frog fencing installed high on the batter of the carriageway formation and some strategic rehabilitation around the bridge abutments, along with some scour protection. Of the six recaptures during this round of monitoring, it was discovered that one of the adult female frogs (735D21B) has moved from approximately 80 m downstream in Year 3 to 70 m upstream in Year 4. For this to have occurred, the frog would have moved beneath the twin bridges and through the area of rehabilitated riparian habitat. This would suggest the mitigation installed at this site has successfully enabled habitat connectivity to be restored.

The control or reference site, Madmans Creek continues to show a more marked variation in frog numbers. The majority of the captures include sub adults and juveniles and an overall two fold increase from the baseline survey. Interestingly, water levels at this site tend to fluctuate more than at Corindi Creek yet there is often evidence of recent breeding events. It is probably the rises and falls of water levels from spring and summer thunderstorms that stimulate more breeding opportunities at this location[1]. Importantly, both sites showed increases and the deviation hasn't exceeded 25% in terms of performance measures.

Site 2 – Dirty Creek (Impact) and Pigeon Gully (Control)

Both treatment classes received extra survey effort with the transect being extended a further 500 m downstream. With this, frogs were rediscovered along the previously unoccupied 500 m transect at Dirty Creek where a Year 4 density of two frogs per 500 m was calculated. Although this might equate to a 60% population reduction from the baseline survey it is an encouraging result from when no frogs were recorded in Year 3. Equally important was the presence of a sub

[1] Females lay their eggs on receding flood waters, the smaller the stream the more often it is likely to rise and fall but also go dry.

adult frog indicating that breeding had occurred in this past season. The extension of the transect to include a further 500 m downstream also yielded frogs indicating the population may occasionally retract during unfavourable seasons.

No frogs were recorded at the nearby control site at Pigeon Gully. This is despite the transect length being extended a further 500 m downstream along with another set of *ad hoc* surveys in late April 2019 around 1.5 km further downstream in an attempt to locate frogs which all proved unsuccessful. Monitoring during an extended period of wet weather may be the only real opportunity to determine whether frogs have disappeared from this part of the Halfway Creek catchment.

Site 3 – Halfway Creek and Yellow Crossing Road (Wooli River)

Halfway Creek and Yellow Crossing Road on the Wooli River continue to provide mixed but positive results during this round of monitoring. At the Halfway Creek impact site, the same marked increase of both adult and sub adult frogs was recorded during Year 4 and this has been a consistent trend over the past three years. Frogs were again consistently found along the full transect gradient and for the first time this included a number of adult males and females using the rehabilitation areas where tube stock plantings grow among jute used to stabilise the stream banks (Plate 3-5). Although in excess of 100 frogs have now been captured and PIT tagged along this transect, none of 10 recaptures show movement from one side of the carriageway to the other. The fact that frogs are now using the rehabilitation areas does suggest this may only be a matter of time.

The reference site at Yellow Crossing Road in the upper Wooli River catchment continues to produce lower numbers of frogs than it did during the baseline surveys. Importantly, there is still some representation of sub adult and juvenile age classes to indicate that breeding adults remain along or adjacent to the transect. Water levels at this site remain very low despite the heavy early summer rains in December 2018 and likely to have produced the a breeding event that yielded the two juvenile frogs captured in the late April 2019 survey. A wet season of average to above average rainfall is probably required for this population to return to a density similar to the baseline survey.

Site 4 – Boneys Creek and Upper Halfway Creek (McPhillips Road)

Monitoring at both Boneys Creek and Upper Halfway Creek continue to yield small numbers of frogs that exceed the density recorded in the baseline survey. At Boneys Creek, this round of monitoring produced two frogs comprising a young adult female and a sub adult from the downstream side of the transect. Frogs continue to remain absent from the upstream side of this transect which is still regarded as marginal habitat.

The reference site of Upper Halfway Creek adjacent to McPhillips Road produced two young adult females and a sub adult frog. Similar to Boneys Creek, all captures took place during the autumn survey indicating some temporal variability in the way frogs use these two sites. Sampling tends to be more productive during post summer sampling than during spring or summer sampling which is often performed during drier conditions.

The following section compares the Year 4 monitoring data against the performance prescriptions outlined in the Threatened Frog Species Management Plan (RMS 2015).

3.5 Performance Indicators and Corrective Actions

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Year 4 monitoring includes the population monitoring, the underpass structure monitoring and riparian habitat monitoring where revegetation works have taken place. Each of these are discussed in the sections below.

3.5.1 Population Monitoring

Both declines and increases were recorded across the monitoring sites and this has been summarised in Table 3-3. Increases were recorded at Corindi Creek (Site 1A), Madmans Creek (Site 1B), Halfway Creek (Site 3A), Boneys Creek (Site 4A) and McPhillips Road (Site 4B). Some of these increases were in the order of 30 times greater than the baseline survey (Halfway Creek), and in doing so, it confirms the large scale variability expected for r selected species which undergo marked fluctuations in population size. At sites with lower densities, this variability can result in counts of zeros as was the case at Dirty Creek in Year 3. During this round of monitoring, there was a return of frogs along the Dirty Creek transect yet it still registered a 60% decline from the baseline surveys. Importantly, frogs have returned to this section of the creek and there has also been evidence of recent breeding. The paired control site at Pigeon Gully has continued to record an ongoing absence of Giant Barred Frogs for the past four years of monitoring, and despite surveys for upwards of 2 km downstream, a population was not found during this round of monitoring. At this site, sampling may only yield frogs once there is a return to average or above average rainfall over the spring, summer and autumn months.

Table 3-3. Mean number of Giant Barred Frogs (inclusive - adults, sub adults, juvenile) during Years 1-4.

Sampling Year	Corindi Creek (Impact)	Madmans Creek (Control)	Dirty Creek downstream (Impact)	Pigeon Gully (Control)	Halfway Creek (Impact)	Yellow Cutting Road (Control)	Boneys Creek (Impact)	McPhillips Road (Control)
	1A	1B	2A	2B	3A	3B	4A	4B
GBF Base	10	7	5	1.5	0.5	29.5	0	0
GBF Year 1 (mean count)	5	4.5	2.5	0	4	1.5	0	0
GBF Year 2 (mean count)	13	17	1.5	0	30.5	12.5	1	0.5
GBF Year 3 (mean count)	12	17	0	0	17.5	9.5	2	4
GBF Year 4 (mean count)	13.5	12.5	2	0	18	7.5	1	1.5
Increase (%)	35%	44%	-	-	3600%	-	100%	100%
Decline (%)	-	-	60%	absent	-	75	-	-

3.5.2 Structure Monitoring

Fourteen frogs captured during Year 4 were recaptures from previous monitoring events and provide opportunities to evaluate the habitat connectivity role of bridges and underpasses for Giant Barred Frog. A summary for each site is provided below.

Corindi Creek - One adult female (735D21B) was recorded moving from approximately 80m downstream to approximately 70m upstream side of bridge between Year 3 and Year 4. As the population is likely to contain less than 100 frogs over this 500m section of creek, this is considered a demonstrated success of the habitat connectivity mitigation measures used at this site. Surveys along the permanent frog exclusion fence found no barred frogs on the road side, however, there were a number of potential breach points, namely where the fence travels over uneven ground such as the bridge abutments covered with large aggregate along with the fact it has been recessed along the ground in the opposite and incorrect way (Plate 3-2). Furthermore, the frog fence between the two carriageways is missing thus enabling frogs to access the carriageway (Plate 3-2).

Dirty Creek – No connectivity structures are relevant to this monitoring transect which focuses on downstream impacts as the highway did not bisect the known population. Similarly, no permanent frog fencing is present.

Boneys Creek – To date, there have been no recaptures at this site nor have frogs been recorded on the upstream side of the carriageway. Surveys of the permanent frog exclusion fence found no barred frogs on the road side, however, there were a number of potential breach points, namely where the fence travels over uneven ground (Plate 3-10).

Plate 3-10. Frog exclusion fence at upstream side of Boneys Creek traversing large aggregate with gaps in the fence.

Halfway Creek – There were six recaptures from previous sampling events during this round of monitoring. All recaptures have remained on their respective side of the carriageway and have showed no sign of moving from one side of the carriageway to the other. The observations of five adult frogs within the rehabilitated areas of jute mesh and plantings does suggest this is likely to change in the near future.

Surveys of the permanent frog exclusion fence found no barred frogs on the road side, however, there were a number of potential breach points, namely where the fence travels over uneven ground, particularly the large aggregate used on the bridge abutments along with the fact that an incorrect frog fence design with large aperture has been used on the northern abutment (Plate 3-11). In reality, these areas would only be used by barred frogs during flood events as individuals move away from the stream bank. Outside of these flood events, the capture data suggests individuals seldom venture further than 20 m from the stream edge whilst these stone abutments are in most cases more than 20 m from the stream. Further monitoring should guide whether or not this fencing extent requires upgrading.

Plate 3-11. Example of an area where large aperture mesh has been used in the frog exclusion fence at Halfway Creek.

3.5.2 Riparian Revegetation Monitoring

Corindi Creek - Planting failures were measured at 5% which is within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. Total weed coverage was measured at 8% and limited to outer edges of planting beds. This is within the accepted tolerance level of 30% cover.

Past bank erosion has been addressed with some large stone pitching and this has improved the stability for revegetation works (Plate 3-6). On the northern downstream bank, tree stumps have been used and this currently appears effective at reducing erosion and associated streambank stability.

Halfway Creek (3A) - Planting failures were measured at 8% and were concentrated to those beds beneath the bridge spans that receive little or no natural rainfall. Despite this, the overall planting failures in the riparian zone are still within the accepted tolerance level of 10% in the first year and 20% over the three year maintenance program. Total weed coverage was measured at 12% and falls within the accepted 30% ground cover tolerance. There was no sign of current bank erosion with some large aggregate used as part of rehabilitating the southern bank.

Boneys Creek (4A) - Planting failures were measured at 10% and fall within the accepted tolerance level whilst the total weed cover was measured at 18% and within the accepted 30% tolerance level. There was no sign of current bank erosion with some large aggregate used to dissipate stream flows during flood events (Plate 3-10).

Table 3-2. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015) for Giant Barred Frog.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Giant Barred Frog Monitoring	Results of Year 4 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frog per Stage 1 survey (breeding survey) (as outlined in Section 4.3).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.	Relevant	Increased numbers of Giant Barred Frogs recorded from the following impact sites: - 1A (Corindi Creek), - 3A (Halfway Creek); - 4A (Boneys Creek). Dirty Creek (impact) declined by 50% in Year 1, further 20% in Year 2, 30% in Year 3 to zero. Frogs rediscovered in Year 4 but 60% decline from baseline survey. Pigeon Gully (control) remained at zero for past 4 years.	i. Natural fluctuations in population with some sites increasing and other decreasing. ii. Small populations likely to undergo more marked variation as observed at Dirty Creek.	Nil. The 60% decline at Dirty Creek is paired with a 100% decline at Pigeon Gully. .
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Monitor twice per year. Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.	Relevant	Corindi Creek – One adult female frog (735D21B) recorded moving from downstream to upstream side of bridge between Year 3 and Year 4. No barred frogs recorded on the road side of the fence. Dirty Creek – No structures relevant. Permanent frog fencing not relevant at this location.	Corindi Creek – Suitable plantings and rehabilitation has provided habitat connectivity. Heavy December 2018 rains provided movement cues for breeding event. Boneys Creek – Habitat upstream is considered marginal with no known occurrences of frogs in this area. May require a seasonal with average to above average rainfall to encourage broader movements. Halfway Creek – Frogs recorded using rehabilitated areas so	Nil.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Giant Barred Frog Monitoring	Results of Year 4 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			Boney Creek – No frogs recorded on upstream side. No barred frogs recorded on the road side of the fence. Halfway Creek – Five frogs recorded in the rehabilitated areas on both sides of carriageway and stream bank. No recorded movement beneath the bridge to date but considered imminent. No barred frogs recorded on the road side of the fence.	evidence of structure use is imminent and likely in Year 5.	
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.	Relevant with all planting beds installed.	Corindi Creek – Planting failures - 5%. Total weed coverage – 8% and limited to outer edges of planting beds. Boneys Creek – Planting failures 10%. Weed coverage 18% with majority between the highway and service road and downstream side of service road culvert. Halfway Creek – Planting failures - 8%. Total weed	Corindi Creek - Natural attrition rate of tube stock plantings combined with extended dry periods. Weeds to be expected as the interface with exotic pasture lands and along a lower order stream. Boney Creek – Natural attrition rate of tube stock plantings combined with extended dry periods. Weeds to be expected as the interface with highway road verge and along a stream with agricultural enterprises in the catchment.	Nil.

Triggers for corrective actions	Corrective actions	Relevance to Year 4 Giant Barred Frog Monitoring	Results of Year 4 Giant Barred Frog Monitoring	Potential Contributing Factors	Corrective Action Required
			coverage – 12% and limited to outer edges of planting beds with perennial grasses and annual weeds.	Halfway Creek - Natural attrition rate of tube stock plantings combined with extended dry periods. Also a number of plantings beneath the bridge which don't receive any rainfall so failing likely to increase with assisted ongoing watering. Weeds to be expected as the interface with exotic pasture lands along a lower order stream.	

3.6 Conclusions and Recommendations

Population monitoring during Year 4 continues to demonstrate the presence and viability of Giant Barred Frog populations bisected to accommodate the Woolgoolga to Ballina Upgrade. With this, populations at Corindi Creek, Halfway Creek and Boneys Creek have generally increased since the initial baseline surveys were performed in 2013 and 2014 (Lewis 2015). On the other hand, the population at Dirty Creek has undergone a constant state of fluctuation with a decline over the past three monitoring years to zero and has recovered in Year 4 with some frogs recorded along the transect. Whilst the population density remains at a 60% decline from the baseline survey, this is likely to change from year to year and is likely to increase back to the baseline levels during a period of average to above average rainfall in the spring, summer and autumn months. Meanwhile, the paired treatment site at Pigeon Gully remains at zero frogs and despite extending the transect a further 500 m downstream along with some targeted survey around 1 to 1.5 km further downstream, the population remains absent. Monitoring during a season with average to above average rainfall is the most likely way to detect frogs at this site.

At this stage of the monitoring program, more than 150 frogs have been micro chipped in and around where operational mitigation devices of bridges, culverts, permanent frog fencing and rehabilitation has been installed. One of the recaptured female frogs at Corindi Creek has moved from downstream of the carriageway to the upstream side of the carriageway since her initial capture in Year 3. This represents the first recorded passage of a Giant Barred Frog following the completion of the mitigative bridge, permanent frog fencing, streambank rehabilitation and frog friendly plantings. Meanwhile at Halfway Creek, five adults were recorded using the rehabilitated planting beds on either side of the carriageway and despite none of the recaptures showing movement from one side of the carriageway to the other, this is likely to occur in the next round of monitoring. Assessing the usefulness of habitat connectivity mitigation remains difficult at Boneys Creek where frogs remain on the downstream side of the carriageway and there is no evidence of the population extending further upstream.

Based on the Year 4 findings, the following recommendation is outlined in Table 3-4.

Table 3-4. Recommendations following Year 4 Giant barred Frog population monitoring and Transport for NSW response.

Recommendation No	Recommendation	Transport for NSW
1.	Revert to transect length of 500m at Pigeon Gully and Dirty Creek.	Adopted - Increasing transect length confirmed the site is a constant state of fluctuation. Agree to revert back to original transect length.
2.	Transport for NSW review the frog fencing design and perform a site inspection to assess fence extents and design for adequacy at Corindi Creek between ch. 3500-3800 with particular attention given around the bridge abutments, Boneys Creek between ch.13250-13350 focusing around the tie in points of the culvert and Halfway Creek between ch. 20700-20900 focusing on the bridge abutments.	Adopted - Transport for NSW will inspect and undertake fencing rectification as required.

4.0 WALLUM SEDGE FROG (*LITORIA OLONGBURENSIS*)

4.1 Species Profile

4.1.1 Description

The Wallum Sedge Frog (*Litoria olongburensis*) is a small species that reaches a maximum length 30 mm. It is smooth light green or light brown above, cream and granular below. A dark brown streak runs from the nostril to the eye, then from behind the eye down the side of the body. From the eye, this streak is bordered below by a raised white stripe that breaks into a series of spots towards the flank. The snout is pointed and undercut and the call is a very rapid buzz, repeated several times (OEH 2014).

Plate 4-1. Adult Wallum Sedge Frog using *Lepironia* sedges growing in standing water to the east of ch. 146500.

Wallum Sedge Frog tadpoles are deep-bodied and high-finned (Anstis 2002). The snout is rounded in dorsal view and rounded to truncate in lateral view. The eyes are laterodorsal and the iris has a broad gold ring around the pupil. Nares open in the anterior direction with a very slight lateral tilt. The dorsum of the tadpole is a dark purple-brown or sooty grey colour with or without darker mottling. The tail, which terminates in a flagellum (long, lash-like appendage), is heavily mottled with dark brown or grey and sometimes orange. The flagellum is usually darkly pigmented and therefore conspicuous in the Wallum Sedge Frog tadpole. The venter is silver-white overlain with a copper sheen that continues halfway up the sides of the body, where it strongly contrasts with the dark dorsal pigmentation. Rolling blue sheen may be visible over the sides of the body. Best seen out of water, this blue sheen extends half-way along the tail. Tadpoles of the Wallum Sedge Frog reach a maximum total length of 37 mm (13 mm body length) and are found hovering in mid-water or, more commonly, resting or grazing on matted sedges (Anstis 2002; Meyer *et al.* 2006).

4.1.2 Distribution

Wallum Sedge Frog Frogs are found in coastal wallum swamps from Fraser Island in southern Queensland to Yuraygir National Park in northern NSW (OEH 2014). Within the W2B corridor they have been previously recorded from Sections 8-10 (Lewis 2014).

4.1.3 Habitat and Ecology

The Wallum Sedge Frog is an "acid" frog confined to the coastal sandplain wallum swamps. Their life-cycle is adapted to the acidic pH (2.8-5.5) of these wetlands. Frogs are highest in abundance in relatively undisturbed wallum swamps. Breeding habitat is characterised by the presence of emergent sedges, with upright species such as *Baumea* spp. and *Schoenus* spp. preferred by adult frogs for perching. Frogs can be found in breeding habitat throughout the year although there appears to be some localised movements during or shortly after rainfall (Lewis and Goldingay 2005). Breeding occurs mainly in spring, summer and autumn after rain. Eggs are laid singly in water at the base of sedges (OEH 2014).

Plate 4-2. Wallum Sedge Frog habitat along the W2B corridor (adjacent ch. 148550).

4.1.4 Conservation Status

The Wallum Sedge Frog is currently listed as Vulnerable pursuant to the NSW *Biodiversity Conservation* Act (1995) and Commonwealth *Environment Protection and Biodiversity Conservation* Act (1999; OEH 2014; DoE 2014). Threatening processes that have been identified include:

- Destruction and degradation of wallum habitat for coastal development;
- Reduction of water quantity and/or quality (including changes to pH) in coastal wetland habitat;
- Changes in average and extreme temperatures and the amount and timing of rainfall due to climate change;
- Severe fires in very dry periods that result in insufficient refuge remaining post-fire;
- Roadkill (it has been estimated that >10,000 Wallum Sedge Frogs are killed annually on one 4km stretch of road near Lennox Head; Goldingay and Taylor 2006); and
- Predation of tadpoles and eggs by the Plague Minnow (*Gambusia holbrooki*). While little is known of the extent of Plague Minnow predation on Wallum Sedge Frogs, it must be considered a potential threat (OEH 2014).

4.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Management Plan (RMS 2013). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

4.2.1 Site Selection and Treatment Design

All five sampling sites known as Site 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A and 5B occur within Section 8-10 (Figure 4-1 & 4-2). Sampling accords with the BACI (Before-After-Control-Impact) approach which consists of the following:

- Impact sites which are identified in this instance with an 'A" and may be potentially impacted by construction works or once the newly constructed carriageway is completed. Potential impacts may include but are not necessarily limited to habitat removal, a reduction in habitat connectivity, increased road strike, facilitating the distribution and increasing densities of exotic predators;
- Reference or control sites which are identified in this instance with an 'B" and possess similar geographic landscape and habitat traits as the impact sites, but are located a sufficient distance (>200 m) and ideally upstream of the Upgrade. If this was not possible, a nearby sub catchment with similar attributes was also considered sufficient.

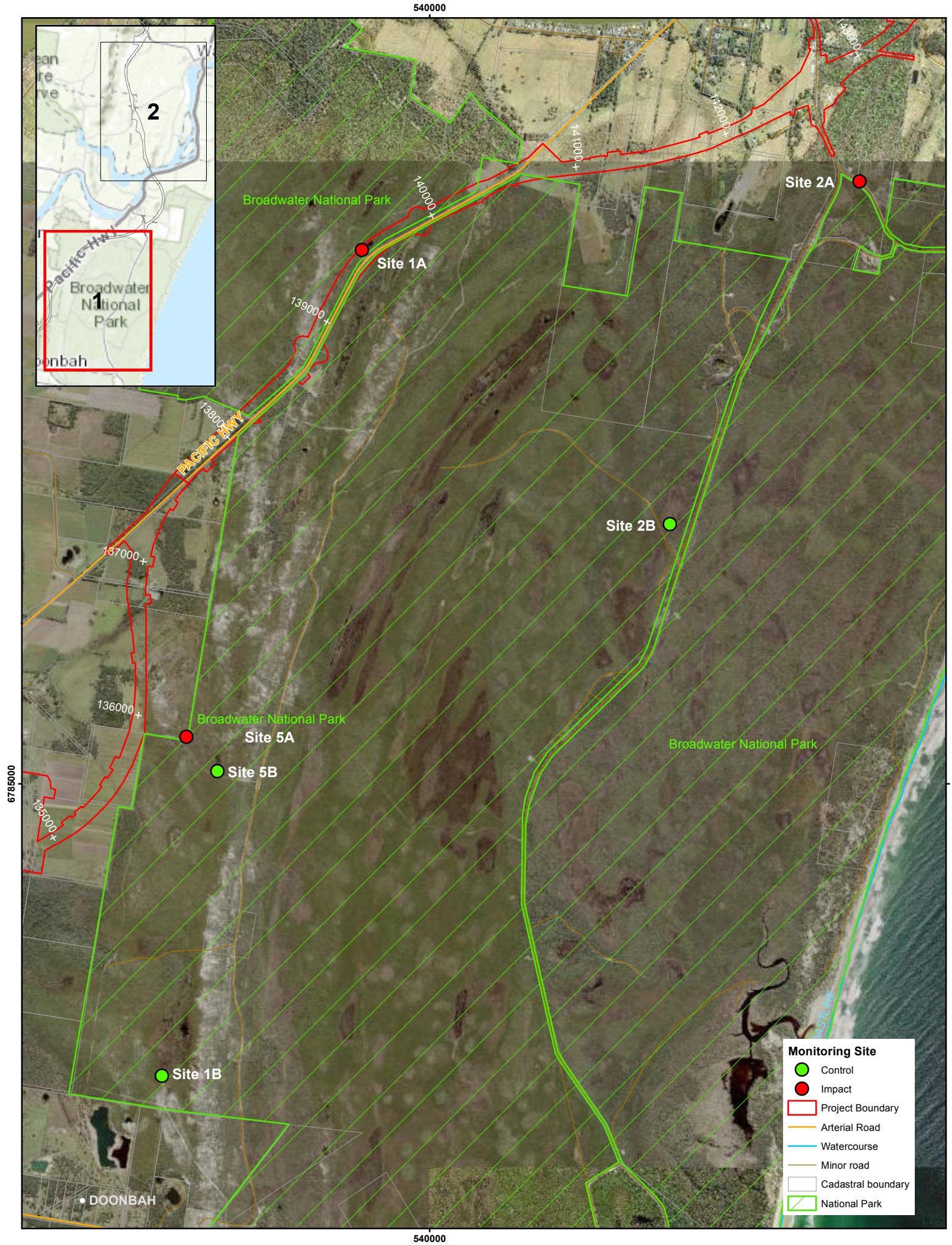
4.2.2 Timing of Surveys

Field surveys were comprised of two sampling periods with each event taking place within 7 days of a 10 mm rainfall event in the past 24 hours. This meant that the summer or calling breeding survey was performed in mid February 2018 and a follow up post breeding survey to determine the level of breeding success was performed at the end of autumn 2018 (Appendix A).

4.2.3 Frog Surveys

Frog surveys were performed in the following manner and in accordance with the required hygiene protocols followed (DECC 2008):

- Surveys were performed generally within 7 days of a notable rainfall event (>10 mm in 24 hrs) using the Bureau of Meteorology (BoM) weather stations at Evans Head (058212; *see* Table A4 in Appendix 3). At other times the BoM website and radar images from Grafton were used to determine more fine scale survey requirements post rainfall;
- Surveys commenced at 30 minutes after dark with the latest surveys being performed up to around 0230 hrs;
- A 50 metre transect was installed at some sites whilst a timed 20 minute search was used as other sites where a 50 m transect could not be installed dur to the small size of the habitat;
- All surveys involved the use of active search with a head lamp (Led Lensor H14R rated 850 lumens); and
- For all frogs that were detected, the age class was determined with:
    - Adults defined as being >16 mm; Sub adult <16 mm; and
    - Juvenile showing some form of a tail tad from recent metamorphosis.



LEWIS ECOLOGICAL

Source:	Aerial Photo: © Land and Property Information 2015 Project Boundary & WSF Survey: Lewis Chainages: RMS 2013
Disclaimer:	This plan is based on or contains data provided by others. GeoView gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
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N W E S

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Meters

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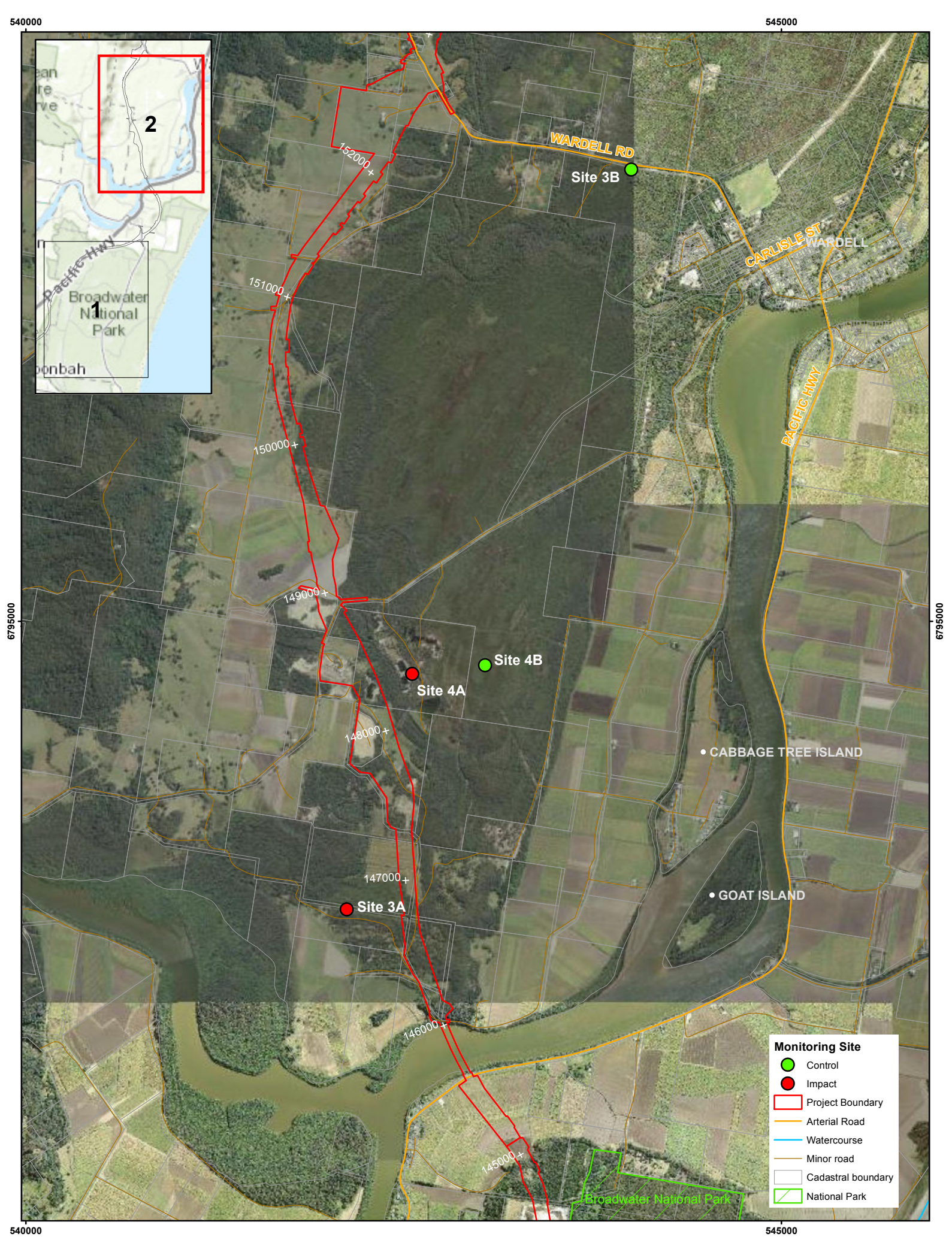
Coordinate System: MGA56 Projection: Transverse Mercator

Sheet 1 of 2

Figure 4-1:

WALLUM SEDGE FROG YEAR 2 MONITORING



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Coordinate System: MGA56 Projection: Transverse Mercator

Sheet 2 of 2

Figure 4-2:

WALLUM SEDGE FROG YEAR 2 MONITORING

4.2.4 Abiotic Data

The following abiotic variables were collected during the survey:

- The amount of rain fall was calculated for the periods 24 hours, 48 hours and 7 days prior to each survey using the weather station at Evans Head (058212);
- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Water level measured with a tape measure generally at the start of the transect or alternatively at the deepest point along the transect;
- pH level measured using a hand held meter, if water was present;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).

4.2.5 Connectivity Structures & Permanent Frog Fence Monitoring

At the time of monitoring, the connectivity structures and permanent frog fencing were not considered complete. Consequently, no monitoring was performed.

4.2.6 Compensatory Breeding Ponds

At the time of monitoring, no compensatory breeding ponds had been constructed for sedge frogs. Consequently, no monitoring was performed.

4.3 Year 2 Construction Monitoring Results

4.3.1 Sedge Frog Abundance

Wallum Sedge Frogs were recorded at 7 (70%) of the 10 monitoring sites during Year 2 (Table 4-1). Sedge frogs were not recorded from Site 2A (Broadwater Beach Road), 3A (Bagotville) and 3B (Wardell Road), whilst the highest counts were recorded in the control sites located in Broadwater National park with 19.5 and 18 frogs per 100m^2 of habitat at Site 2B and 5B respectively (Figure 4-3). Overall, sedge frog numbers remained lower in Year 2 than the baseline surveys, but were generally higher than recorded for Year 1

Adult frogs were recorded at all seven sites and were recorded during both the summer (survey 1) and the late autumn/winter (survey 2) surveys. Sub adult frogs were recorded at only three sites (1A, 2B, 5B), yet interestingly, this age class was recorded at Site 2B and 5B during both sampling periods indicating breeding had occurred twice. Juvenile frogs were recorded at four sites (1B, 2B, 4A, 5B) and were only recorded during the late autumn/winter survey indicating breeding had occurred sometime in early autumn. No tadpoles were recorded during either of the surveys.

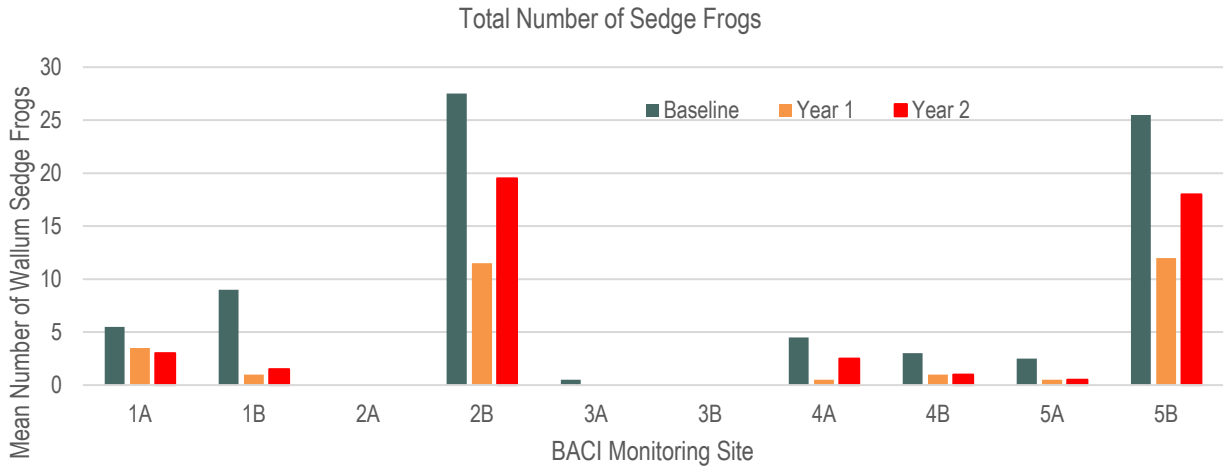


Figure 4-3. Wallum sedge frog counts between baseline survey, Year 1 and Year 2 monitoring.

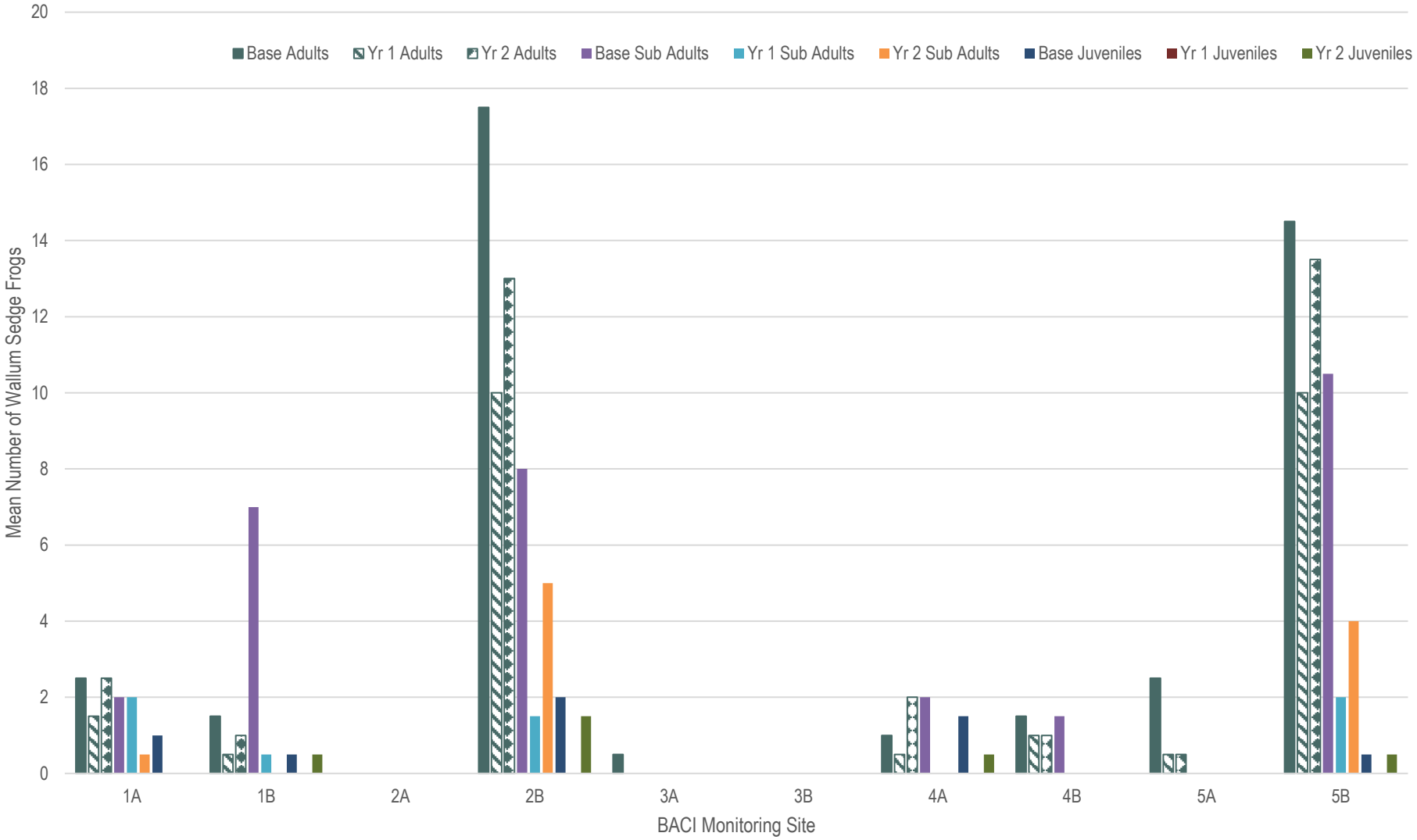


Figure 4-4. Wallum sedge frog counts across three age classes between baseline survey and monitoring in Year 1 and 2.

Table 4-1. Summary of the sites where Wallum Sedge Frogs were detected.

BACI Site	Treatment Class	Site Name	Chainage Extent	Base Adults	Yr 1 Adults	Yr 2 Adults	Base Sub Adults	Yr 1 Sub Adults	Yr 2 Sub Adults	Base Juveniles	Yr 1 Juveniles	Yr 2 Juveniles
1A	Impact	Broadwater West	139500	2.5	1.5	2.5	2	2	0.5	1	0	0
1B	Control	Broadwater West	133000–132000	1.5	0.5	1	7	0.5	0	0.5	0	0.5
2A	Impact	Broadwater Beach Road	143000–142000	0	0	0	0	0	0	0	0	0
2B	Control	Broadwater East	137000-138000	17.5	10	13	8	1.5	5	2	0	1.5
3A	Impact	Bagotville	146000-147000	0.5	0	0	0	0	0	0	0	0
3B	Control	Wardell Road	151000-152000	0	0	0	0	0	0	0	0	0
4A	Impact	Ballina Shire Council Quarry	148000-149000	1	0.5	2	2	0	0	1.5	0	0.5
4B	Control	Jali Land	148000-149000	1.5	1	1	1.5	0	0	0	0	0
5A	Impact	McDonalds	135900	2.5	0.5	0.5	0	0	0	0	0	0
5B	Control	Broadwater National Park	135800	14.5	10	13.5	10.5	2	4	0.5	0	0.5

4.3.2 Constructed Breeding Ponds

At the time of monitoring, no compensatory breeding ponds had been constructed for sedge frogs.

4.4 Discussion

Sampling during Year 2 found sedge frog numbers remain markedly lower than they did during the baseline surveys. There has, however, been some improvement in frog numbers since Year 1 with recorded increases at Site 1B (Broadwater West), 2B (Broadwater East), 4A (Ballina Shire Council/Jali) and 5B (Esk Firetrail). Sedge frogs remain absent from Site 2A (Broadwater Beach Road) which is reliant on higher water tables associated with above average seasonal rainfall. On this occasion, the monitoring transect was dry and this habitat seldom supports sedge frogs (Lewis and Goldingay 2005). A similar situation exists at Site 3A (Bagotville) where no sedge frogs were recorded along the dry and partly mown transect. Despite Site 3B (Wardell Road) containing at least some surface water, no sedge frogs were recorded. At this site, there does appear to be a lot of interspecific competition for resources along the monitoring transect, with increasing numbers of Eastern Sedge Frog (*Litoria fallax*) and Tylers Tree Frog (*Litoria tyleri*).

No compensatory breeding ponds had been constructed at the time of monitoring. Work on these should be prioritised as compensatory frog ponds for this species can be difficult to construct and get right in relation to drying periods, correct vegetation type and acceptable pH which is an important attribute to reduce competitor interactions from non-acidic frog fauna including Eastern Sedge Frog (*Litoria fallax*) and Tylers Tree Frog (*Litoria tyleri*). Lessons from the Tugun Bypass should be applied in this instance.

How the data compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

4.5 Performance Indicators and Corrective Actions

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Year 2 monitoring includes the population monitoring component, but not the connectivity structures, compensatory ponds and revegetation works given they are not yet complete (RMS 2015). The performing factor for the population monitoring is the number of Wallum Sedge Frogs per 100 m2 of habitat. With this, the numbers or actual counts of sedge frogs has declined in a relative manner across both the impact and control sites. For example, no sedge frogs were recorded at either Site 3A (Bagotville) or Site 3B (Wardell Road) yet both historically contained small numbers of frogs. The corrective action itself is to be assessed at the completion of Year 3 monitoring of which there are four options outlined in Table 4-2.

Table 4-2. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015) for Wallum Sedge Frog.

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Wallum Sedge Frog Monitoring	Results of Year 2 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.	Relevant	Wallum Sedge Frogs absent from Site 2A, 3A and 3B. Compared to the baseline survey, Wallum Sedge Frogs declined across all three age classes at the remaining seven sites. Sedge frogs were absent from Site 2A and 3B in the pre-construction baseline surveys. Site 5A has declined by 80% whilst 5B has declined by 21% to show a 59% decline at the impact site. This exceeds the acceptable 25%.	Surveys being performed during seasonally dry conditions when there is no or very little surface water at the monitoring sites. Typically frogs occupy vegetated wetlands with freestanding water (*see* Lewis and Goldingay 2005). At Site 5A, the population density is heavily influenced by the amount of free standing water so the recorded decline is a natural fluctuation associated with ground/surface water.	Wait until Year 3.
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not damaged, and connectivity structure is operating correctly). Monitor twice per year.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Wallum Sedge Frog Monitoring	Results of Year 2 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
	Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.				
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar wetlands or is unsuitable for frog occupation.	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
No persistent water present in ponds (negative hydro period) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from monitoring events), water quality or	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.

Triggers for corrective actions	Corrective actions	Relevance to Year 2 Wallum Sedge Frog Monitoring	Results of Year 2 Wallum Sedge Frog Monitoring	Potential Contributing Factors	Corrective Action Required
associated vegetation) as detailed in section 5.4.4.					
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.	Not relevant at this point in time.
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.	Not applicable as site not in riparian habitat.	Not Applicable	Not Applicable	Not Applicable

4.6 Conclusions and Recommendations

Construction monitoring during the summer and late autumn and early winter of 2018 found sedge frogs at seven of the 10 monitoring sites. Their continued absence from Site 2A and both of the Site 3 treatments reflects small populations that rely on source populations from nearby locations. Whilst there has been a recorded overall decline in sedge frog numbers in Year 2, it is important to note that these declines extend to the adjacent reference sites. Furthermore, recruitment in the form of sub adult and juvenile frogs was recorded at half of the monitoring sites and evidence of recruitment at other sites is likely to occur during Year 3.

No compensatory ponds have been constructed to date. Consideration should be given to establishing ponds early during the construction phase so that the difficulties can be more readily addressed ahead of the operation phase. Some settling time is required and this will take additional time should the process occur during an extended period of below average rainfall.

At Year 2, the performance indicators of the monitoring program are yet to be measured with corrective action and their consequences. This is required at Year 3 so that any seasonal or external effects are adequately considered.

Based on the Year 2 findings, the following recommendation is outlined in Table 4-3.

Table 4-3. Recommendations following Year 2 Wallum Sedge Frog population monitoring and Transport for NSW response.

Recommendation No	Recommendation	Transport for NSW
1.	Ensure construction of the compensatory breeding ponds commence early in the construction program in accordance with the Threatened Frog Management Plan which states this will be "*finalised during the detailed design of these areas of the project*"	Noted - Compensatory ponds will installed in accordance with the Threatened Frog Management Plan.

5.0 GREEN-THIGHED FROG (*LITORIA BREVIPALMATA*)

5.1 Species Profile

5.1.1 Description

The Green-thighed Frog is a small to medium sized (max. 47 mm) hylid frog (Barker *et al.* 1995; Cogger 1995; Murphy and Turnbill 1999; Lemckert *et al.* 2006). It is a relatively distinct species with a prominent white upper lip, armpits and groin marked in lime green or yellowish in some instances but always with black markings (Barker *et al.* 1995; Lemckert *et al.* 2006).

Plate 5-1. Green-thighed Frog.

5.1.2 Distribution

The Green-thighed Frog is distributed in coastal and sub coastal areas from near Bundaberg (Cordalba) in the north to Ourimbah (i.e. central coast NSW) in the south (Barker *et al.* 1995; Lemckert *et al.* 2006). Despite this relatively wide distribution, it is known from few areas (*see* Ehmann 1997).

5.1.3 Habitat and Ecology

The cryptic habits of the Green-thighed Frog ensured it remained unknown to science until 1972 (Tyler *et al.* 1972). The main habitat requirement of this species is warm temperate lowland forest, although more recent records have indicated other habitat types including dry sclerophyll forest, heathland and swamp forest are used (Nattrass and Ingram 1993; Lemckert 1999; Murphy and Turnbill 1999; Lewis 2000; Lewis 2006). The Green-thighed Frog is most often detected during breeding events between October and April when males congregate around flooded depressions and call from either the ground or low fallen branches or vegetation (Barker *et al.* 1995; Ehmann 1997; Lemckert *et al.* 2006). Typically, calling events occur when the breeding site has received at least 75 mm in 24 hours or around 150 mm over a 72 hour period (B. Lewis unpublished data).

5.2 Survey Methods

Field surveys were performed in accordance with the Threatened Frog Species Management Plan (RMS 2015). The following details the areas surveyed along with the timing of field surveys and how the data were treated or analysed.

5.2.1 Site Selection

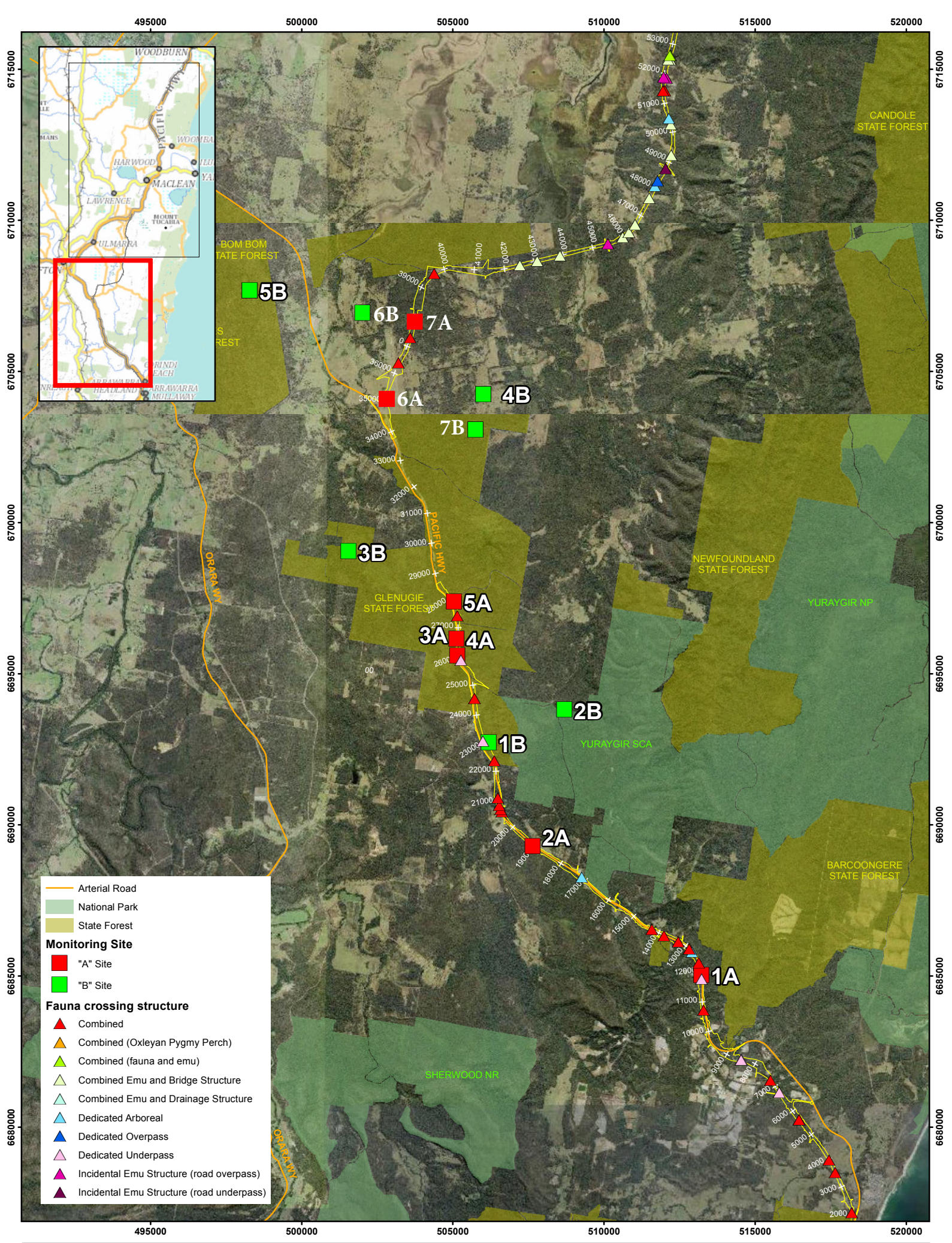
The location of BACI sites 1-5 are located in Section 1 and 2 whilst sites 6 to 10 are located in Section 3-7 and were selected during follow up surveys and updating of baseline information in 2015 (Lewis 2015; Figure 5-1).

5.2.2 Timing of Surveys

Weather patterns were constantly monitored between October 2018 through to May 2019 for the suitability of implementing field surveys during or immediately after a rainfall event delivering >50-75 mm in 24 hours, or alternatively 150 mm over 72 hours (Table A1). Consequently, stage one sampling took place on the 17-19th of December 2018 for Sites 1-8 and the 3rd and 4th April at Site 9 and 10. No sampling was performed at Site 6A due to ongoing access constraints.

During stage one calling surveys, each site was visited and an initial five minute listening survey was performed to identify calling individuals. This was followed by a search of any flooded habitat to visually identify any non-calling individuals present in and around the flooded areas. Searches of the adjacent permanent frog fence were also performed at this time. Where the entirety of the fence extent couldn't be completed, it was surveyed 1-2 days later. At each site, the following was recorded: time at start and end of survey for each survey site, conditions during the survey (including temperature, humidity, cloud cover, relative wind intensity and rainfall) and species of frogs calling.

The second round or post breeding surveys were used to measure the breeding success at each site and these were performed on the 16th January 2019 for Sites 1-8, or around 30 days after the potential breeding event. This was brought forward due to the dry ongoing conditions resulting in the ponds drying out quicker than had been anticipated. Another survey was performed on the 5th February 2019 to gauge the status of those ponds which contained at least some water during the survey on the 16th January 2019. During the post breeding surveys, a fine scale mesh net (400 mm diameter) was used to sweep any of the residual water body. In an attempt to standardise this method, a minimum of 10 sweeps was undertaken per 25m^2 of water body. Any tadpoles captured were examined to determine if they were hylids representative of Green-thighed Frog, and if so, a sample was taken for further identification. The bank area within 5-10 m was also traversed to visually search for metamorphosed froglets over a set 20 minutes per site and the number of frogs recorded.



LEWIS ECOLOGICAL

Source:	Aerial Photo: © Land and Property Information 2015 Green-thighed Frog Pre-construction Baseline Monitoring: Lewis Ecological 2015 Project Boundary & Chainages: RMS 2013 National Parks: NSW NPWS 2011 State Forests: Forestry Cooporation 2006
Disclaimer:	This plan is based on or contains data provided by others. GeoView gives no warranty in relation to the data (including accuracy, reliability, completeness, currency or suitability) and accepts no liability (including without limitation, liability in negligence) for any loss, damage or costs (including consequential damage) relating to and use of the data. Data must not be used for direct marketing or be used in breach of privacy laws.
File:	2681617-FIG-1-1-GTF-BASELINE-MONITORING-160810

N W E S

0 1 2 3 4

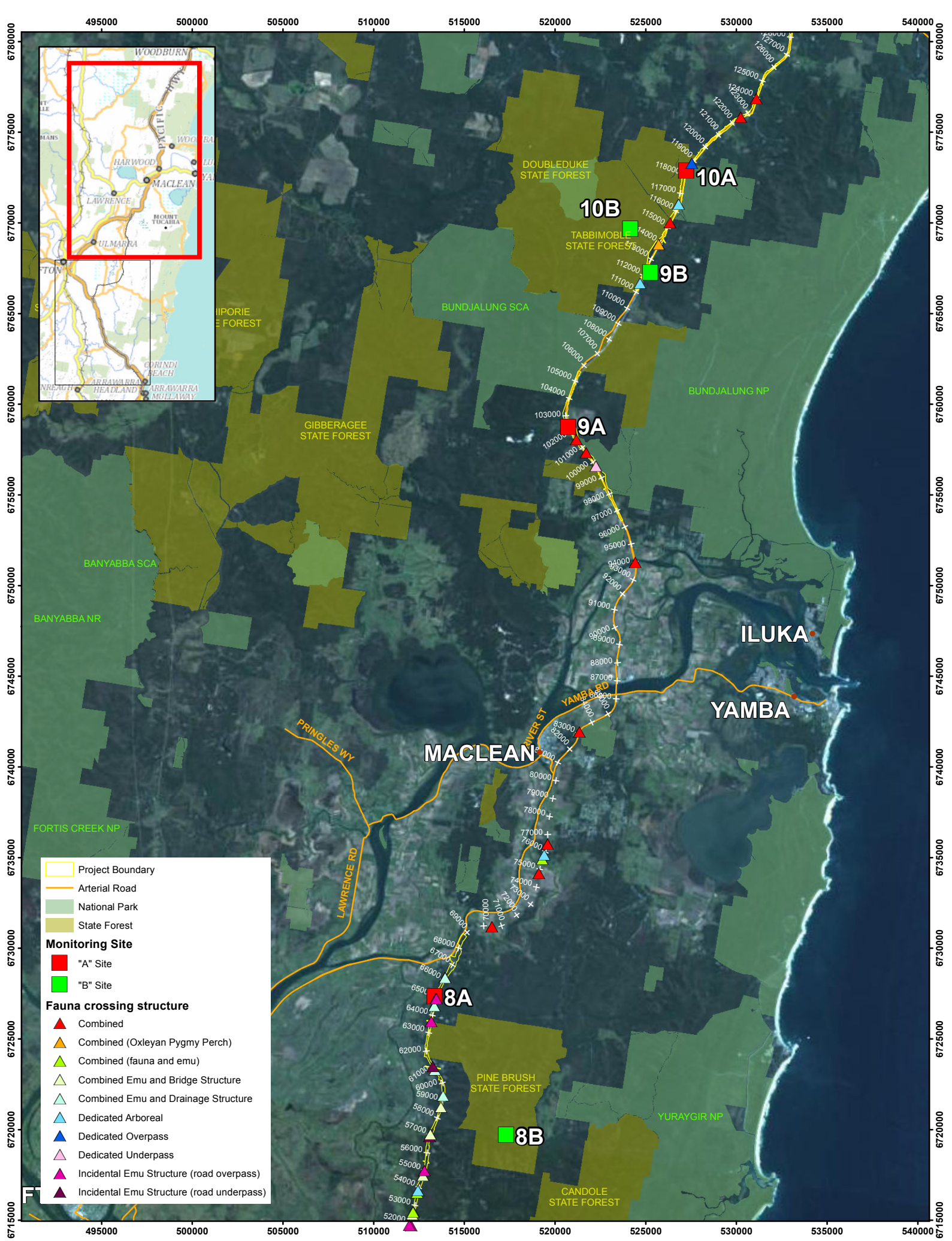
Kilometers

A4 Scale 1:150,000

Coordinate System: MGA56 Projection: Transverse Mercator

Figure 5-1:

GREEN-THIGHED FROG MONITORING SITES



LEWIS ECOLOGICAL

Source:	Aerial Photo: © Land and Property Information 2015 Green-thighed Frog Pre-construction Baseline Monitoring: Lewis Ecological 2015 Project Boundary & Chainages: RMS 2013 National Parks: NSW NPWS 2011 State Forests: Forestry Cooperation 2006
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Kilometers

A4 Scale 1:250,000

Coordinate System: MGA56 Projection: Transverse Mercator

Figure 5-2: Sheet 2 of 2

GREEN-THIGHED FROG MONITORING SITES

5.2.3 Abiotic Data

The following abiotic variables were collected during the survey:

- Air temperature (°C) measured with a thermometer at the start and finish of the frog survey and averaged;
- Relative humidity (%) measured with wet/dry bulb thermometer at the start and finish of the frog survey and averaged;
- Prevailing cloud cover was expressed as a percentage (%) coverage of the sky;
- Wind speed measured using a subjective scale (0 = no wind, 1 = light rustles of leaves on trees, 2 = leaves and branches moving and 3 = whole canopy moving); and
- Rain fall was also measured in a subjective scale (0 = no rain in past 24 hours, 1 = rain within 24 hours and 2 = rain during survey).
- Seasonal rainfall data was also collated for the period between September 2018 and the end of May 2018 to assess when the surveys were performed and how they compared to other rainfall events within the perceived breeding period. The data were collated from Grafton Airport (058161) for the southern sites and from New Italy (058097) for the northern sites.

5.2.4 Connectivity Structure Monitoring

Ten connectivity structures have been nominated for Green-thighed Frog monitoring and extend from ch. 19180 (BACI Site 2A) to 118464 (BACI Site 10A). The southern three structures (ch.19180 to 27420) were surveyed on the 19th and 20th of December 2018 to coincide with the breeding event from the heavy rainfall received over the 17th and 18th of December 2018. At each of these sites, a 20-25 min search was used to detect frogs within 100 m of the connectivity structure. Captured frogs were toe clipped with a single digit partially removed before the wound was dressed with Vetbond surgical adhesive. Frogs captured on the eastern side of the carriageway were marked on their left hand using the outer finger. Frogs captured on the western side of the carriageway were marked on their right hand using the outer finger.

5.3 Monitoring Results

5.3.1 Stage 1 Surveys - Calling Intensity and Spotlighting

Green-thighed Frogs were recorded at 12 (63%) of the 19 sites as part of Year 4 monitoring in Sections 1 and 2 and Year 3 in Sections 3-7 (Table 3-1; Figure 3-1). Frogs were recorded from five (55%) of the impact sites including the newly relocated Site 3A (Bald Knob Tick Gate Road ch. 25000) where ponds have recently been constructed (i.e. winter 2018). Frogs were recorded from seven (70%) of the control sites. No surveys were conducted at Site 6A due to continuing access restrictions. At Site 8A (Tyndale Crown Reserve ch. 64700), at least two male frogs were heard calling from a private property adjacent to the road corridor where access constraints prevented a spotlight of this area. At Site 3B (Glenugie west), frogs were observed but not heard calling whilst frogs were both heard and observed at the remaining 11 sites.

Amplecting or mating frogs were recorded from Site 3A (Bald Knob Tick Gate Road) and 6B (Airport Road) on the 18th December 2018 whilst another amplecting pair were recorded from Site 9B (Tabbimoble east) on the 3rd April 2019. At these three sites, counts were in excess of five frogs with numbers approaching at least 20 at Site 6B on Airport Road. At the remaining sites, counts generally comprised less than five frogs.

Plate 5-2. Green-thighed Frogs recorded during the survey with a male (left) from Site 6B (Airport Road) and a female (right) from Site 5B (Stockers Road) in Bom Bom State Forest.

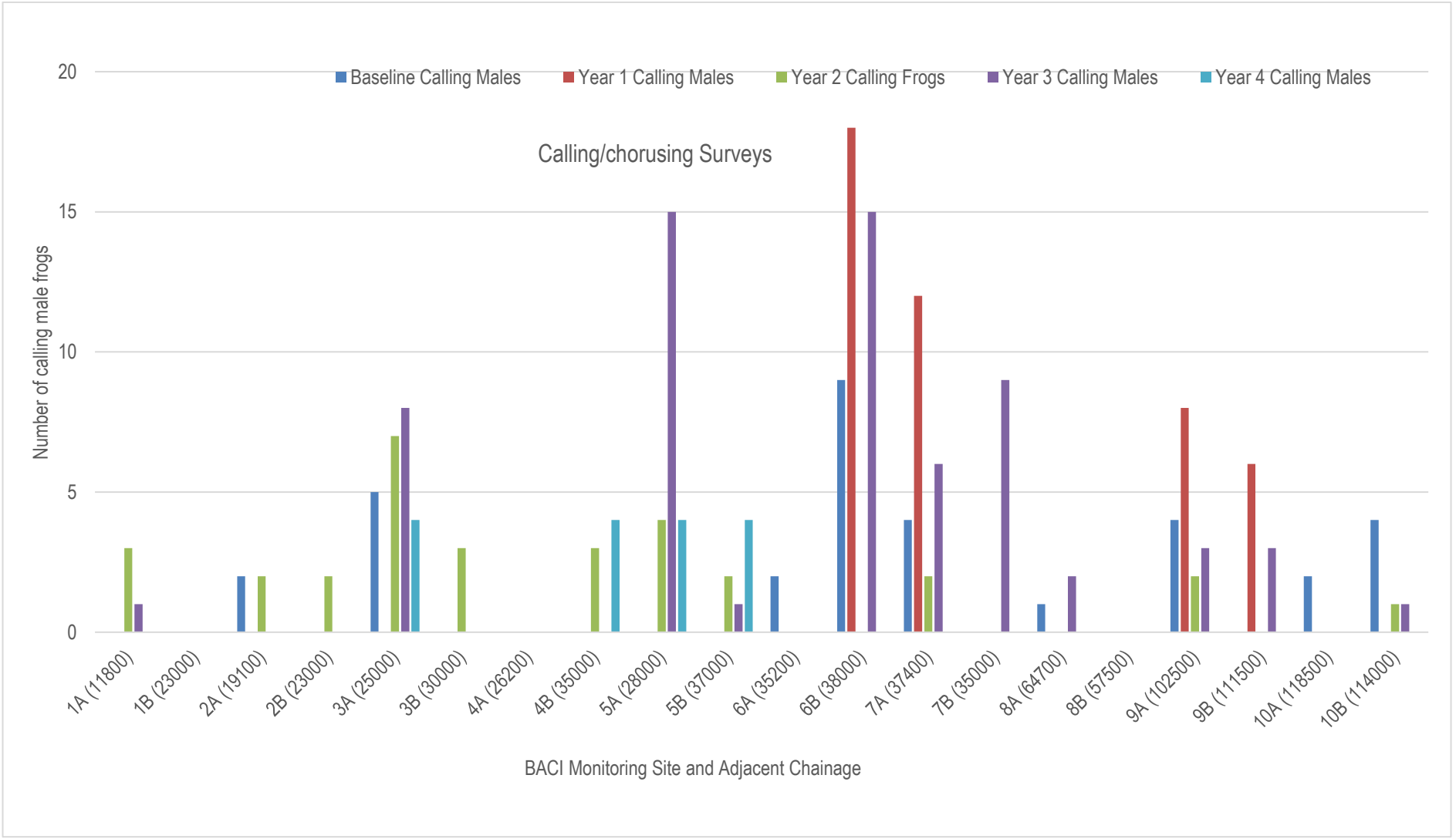

Figure 5-3. The number of Green-thighed Frogs observed between the pre construction surveys and construction/operational monitoring in Years 1-4 at Sites 1-5 and Years1-3 at Sites 6-10.
Note – Site 6A has had no monitoring performed since the baseline due to access limitations.

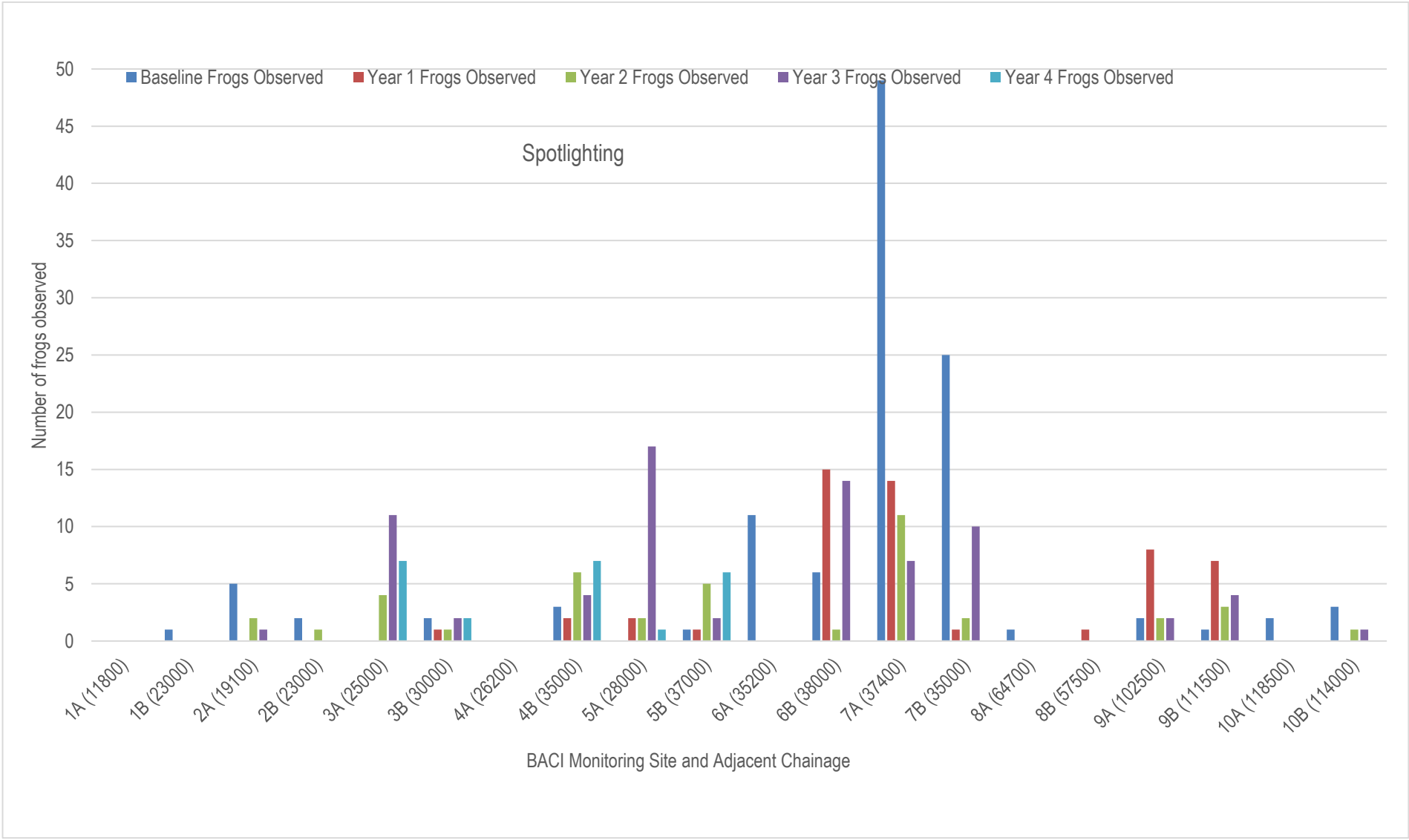

Figure 5-4. The number of Green-thighed Frogs observed between the pre construction surveys and construction/operational monitoring in Years 1-4 at Sites 1-5 and Years1-3 at Sites 6-10. Note – Site 6A has had no monitoring performed since the baseline due to access limitations.

Table 5-1. Summary of the 2018/2019 Green-thighed Frog surveys for BACI Sites 1-10.

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
1A ch.11800	17.12.2018	0	0	16.01.2019	0	0	0	i. Permanent frog fencing installed adjacent to the compensatory breeding ponds. ii. Compensatory ponds constructed on western side. iii. New ponds have been desilted and reconstructed.	Frogs are likely to opportunistically breed through the broader area so reliable and repeated sampling likely to remain difficult. Newly constructed ponds may increase site suitability.	No
1B ch.23000	17.12.2018	0	0	16.01.2019	0	0	0	i. Site is impacted by works and not considered a control site.	Site not considered a control site. It is immediately adjacent to the clearing footprint for the Upgrade and therefore an impact site. Adopted recommendation to find suitable alternative control site has been implemented but no suitable site has been found.	No
2A ch.19100	17.12.2018	0	0	16.01.2019	0	0	0	i. Permanent frog fencing observed on both sides of the carriageway in both Giant Barred Frog and Green-thighed Frog configurations. ii. Compensatory ponds constructed on western side towards southern extent of frog exclusion fencing. iii. Culvert underpass provides some habitat connectivity.	Area appears to dry more rapidly than previously. Adjacent table drains probably increased drainage in this area. The compensatory breeding ponds tend to dry rapidly at this site and require ongoing follow up rainfall to ensure they retain water for at least 30-35 days.	Yes
2B ch.23000	17.12.2018	0	0	16.01.2019	0	0	0	Outside works footprint.	Site only appears to be occasionally used by frogs and more so during thunderstorms in dry seasons as the main monitoring pond fills up rapidly. Suspect other locations used nearby.	Yes
3A ch.25000 (new)	18.12.2018	4	7	16.01.2019	0	0	0	i. Newly constructed compensatory breeding ponds installed in late winter 2018.	Frog population still appears to be functioning in a viable manner with breeding frogs recorded in previous monitoring year.	Yes

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
								ii. Permanent frog fencing observed. iii. RCP culvert located 250 m to the south as a form of habitat connectivity.		
3B ch.30000	19.12.2018	0	2	16.01.2019	0	0	0	Outside works footprint.	Site burnt since initial 2013 surveys and likely to have influenced frog numbers. Difficult site to pin point breeding areas and likely to vary based on extent of seasonal heavy rains, depressions left from upturned trees and localised earthworks and associated drainage.	Yes
4A ch.26200	18.12.2018	0	0	16.01.2019	0	0	0	i. Permanent frog fencing partly installed.	Area prone to ongoing disturbance due to its proximity to road verge and routine maintenance or vehicles parking off the shoulder. The retained breeding area is now located in a vegetated median isolated by north bound and south bound carriageways.	No
4B ch.35000	18.12.2018	4	7	16.01.2019	0	0	0	Outside works footprint.	Frogs are generally scattered throughout this section of Glenugie State Forest. Frog counts influenced heavily by prevailing rainfall conditions and season as individuals are expected to breed at other nearby locations and not the monitoring site.	Yes
5A ch.28000	18.12.2018	4	1	16.01.2019	0	0	0	i. Permanent frog fence installed. ii. No compensatory ponds installed due to natural depressions that provide the same function and are currently used by frogs.	No Green-thighed Frogs recorded on the roadside of frog fence although a number of common species were observed. Numbers of wild horses accessing the ponds to drink appears to have reduced the water holding period during this round of monitoring.	Yes

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
6A (35200)	no data - site restrictions still in place	-	-	no data - site restrictions still in place	-	-	-	No access permitted to this area	No access permitted to this area. Likely to have successfully bred at this monitoring location given the results from the surrounding sites.	Yes
6B (38000)	19.12.2018	4	6	16.01.2019	0	0	0	Outside works footprint but close to Airport Road.	Site immediately adjacent to Airport Road which continuously provides a good barometer of local Green-thighed Frog activity. Breeding site probably benefits from road runoff.	Yes
7A (37400)	18.12.2019	15	14	16.01.2019	0	0	0	i. Permanent frog fencing installed.	Potential breeding area is not well defined but numbers of frogs suggest this area as a 'hotspot' in 2015 (Lewis 2015). Compensatory ponds recommended at this site. Insufficient follow up rainfall contributed to reduced breeding success.	Yes
7B (35000)	19.12.2018	6	7	16.01.2019	0	0	0	Outside works footprint.	Site logistically difficult to access during rainfall events.	No
8A (64700)	19.12.2018	9	10	16.01.2019	0	0	0	i. Permanent frog fence installed. ii. Access road graded which has reduced its suitability for Green-thighed Frogs based on past observations.	Frog fence appears to function in an effective manner. Frogs at this site appear to vary their breeding location based on extent of rainfall. Frogs heard calling from adjacent private property during this monitoring period.	No
8B (57500)	19.12.2018	2	0	16.01.2019	0	0	0	Outside works footprint.	Site is seasonally grazed by cattle and with this the pond forms a watering source and tends not to last more than two weeks. Frogs appear to vary their breeding site and with drier seasons, the calling/breeding site now appears to occur in the drainage line around 300 m to north.	No
9A (102500)	19.12.2018	0	0	16.01.2019	0	0	0	i. Permanent frog exclusion fencing observed.	Presence of frogs adjacent to the clearing indicates the population extends further to the west.	No

	Stage 1 – Calling/Breeding Surveys			Stage 2 – Post Breeding Follow-up Survey						
BACI Site	Date	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Date	SA	Juv	Tads	Frog Management Mitigation Observed or Recorded	General Comments	Presence of Green-thighed Frogs Confirmed in 2015 (Baseline Surveys Lewis 2015)
								ii. The installed RCP culverts provide marginal opportunity at improving habitat connectivity.		
9B (111500)	03.04.2019	3	2	15.05.2019	0	0	0	Outside works footprint.	Frogs are generally scattered throughout this section. Two breeding sites identified and had retained water for the post breeding survey in May 2019.	No
10A (118500)	03.04.2019	3	4	15.05.2019	0	0	0	i. Permanent frog fence installed on the western side where the monitoring site was previously located.. ii. Bridge structure was partly completed.	Old breeding pond has been removed to accommodate the north bound carriageway. The survey now focuses in and around the drainage line to the west.	Yes
10B (114000)	04.04.2019	0	0	15.05.2019	0	0	0	Outside works footprint	Calling or breeding location varies markedly within this area and tends to be influences by the extent of road maintenance works and the amount of prevailing rainfall.	No

5.3.2 Stage 2 Surveys – Post Breeding Counts of Tadpoles and Froglets

No tadpoles or juvenile frogs were recorded during this round of monitoring (Table 5-1). The breeding sites were predominantly dry by the time 30 days had elapsed without follow up rainfall at Site 1-8 (Appendix A-2). With the delayed sampling at Site 9 and 10 up until mid May 2019, some water was present, yet no tadpoles or froglets were recorded.

5.3.3 Seasonal Rainfall and Associated Survey Conditions

Suitable seasonal conditions in the form of heavy rainfall events exceeding 50 mm in 24 hours or cumulative tallies exceeding 150 mm in 72 hours occurred on only one occasion during this monitoring period (Table A-2). Rainfall events exceeding 50 mm in 24 hours occurred on the 17th December (131 mm) and not again for the remainder of the season. At Sites 9 and 10, a single event occurred late in the season on the 3rd April 2019 (62 mm).

5.3.4 Constructed Breeding Ponds

No Green-thighed Frogs were recorded breeding in the constructed ponds at Redbank Creek (ch. 5600 E) nor at Site 1A (ch.11800 W), Site 2A (ch. 19100 W) and Site 3A (ch. 25000). A summary of the site inspections is presented below and summarised in Table 5-2.

i. Redbank Creek Ponds (5600 E)

Monitoring commenced on the evening of the 18th December 2018 where all four ponds had filled to capacity following an estimated 100 mm of rainfall in the past 24 hrs. At this time, no Green-thighed Frogs were heard or observed around the ponds although a couple of males were heard calling from the western side of the carriageway.

A follow up survey 30 days later on the 16th January revealed three of the ponds had dried out completely, whilst the fourth pond contained around 50 mm of water (Plate 5-3). Three juvenile Broad-palmed Frog (*Litoria latopalmata*) were recorded around the *Juncus* sedges growing at the edge of this pond. Importantly, the ponds are drying at differing rates so in this context it meets the design intensions of the Threatened Frog Management Plan.

Plate 5-3. Pond inspection in mid January 2019 showing ponds with and without water at Redbank Creek ch. 5600.

ii. Falconers (11800 W)

Monitoring commenced on the evening of the 18th December 2018 where all five ponds had filled and over flowed following an estimated 100 mm rainfall event. No Green-thighed Frogs were heard calling from around the ponds.

A follow up survey 30 days later on the 16th January revealed four of the ponds had dried out completely, whilst the fifth pond contained around 50 mm of water and was occupied by Common Eastern Froglet (*Crinia signifera*) and Broad-palmed Frog metamorphs, tadpoles and at least two metamorphs (Plate 5-4). Importantly, the ponds are drying at differing rates so in this context it meets the design intensions of the Threatened Frog Management Plan.

Plate 5-4. Pond inspection in mid January 2019 showing ponds with and without water at Falconers ch. 11800.

iii. Halfway Creek (19100 W)

Monitoring commenced on the evening of the 18th December 2018 where three ponds had filled and over flowed following an estimated 100 mm rainfall event. No Green-thighed Frogs were heard calling or observed around the ponds.

A follow up survey 30 days later on the 16th January revealed all three ponds had dried out completely. This appears to be a consistent trend at this site with ponds drying prematurely if substantial follow up rain isn't received within 3 weeks of the potential breeding event. Some intervention such as the application of bentonite is probably required at this site as additional earthworks are probably too close to services including the optic fibre.

iv. Bald Knob Tick Gate Road (25000 E)

Monitoring commenced on the evening of the 18th December 2018 where all five ponds had filled to capacity following an estimated 125 mm of rainfall in the past 24 hrs. At this time, no Green-thighed Frogs were heard or observed around these newly constructed ponds, however, several males were heard and observed calling from a disused borrow pit around 30 m to the west.

A follow up survey 30 days later on the 16th January revealed four of the ponds had dried out completely, whilst the fifth contained approximately 50 mm of water (Plate 5-5). One of the dried pond had recently dried indicating the five ponds dry at varying rates, an intended design outcome outlined in the Threatened Frog Management Plan.

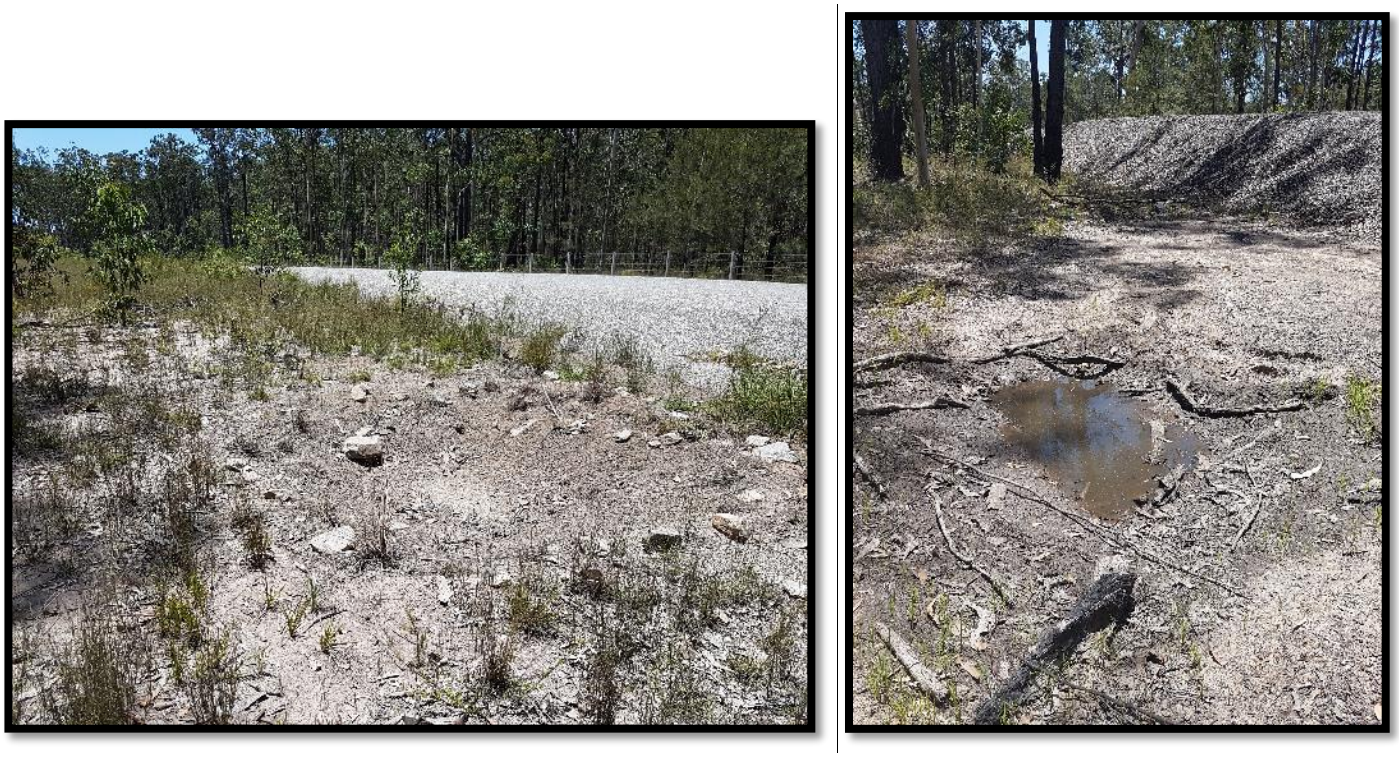

Plate 5-5. Pond inspection in mid January 2019 showing ponds with and without water at Bald Knob Tick Gate Road ch. 25000.

v. Compensatory Ponds in Sections 3-7

At the time monitoring was performed, no compensatory breeding ponds had been constructed.

Table 5-2. Summary of compensatory frog pond monitoring during Year 4.

Site	Ch. + Side of Carriageway	Number of Constructed Ponds	First Survey	Second Survey	Third Survey	Comments
Redbank Creek	5600 East	4	18th December 2018 All ponds filled to capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	16th January 2019 Three ponds receded 100% and dry whilst fourth pond contained around 50 mm water and 30% capacity. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	5th February 2019 Forth pond receded to ~10% capacity but still capable of supporting tadpoles. Visual Water Quality – same as adjacent Redbank Creek and flooded depressions.	Without follow up rain, ponds likely to dry within 30 days. The fourth pond works well for below average rainfall events.
Falconers	11800 West	5	18th December 2018 All ponds filled to capacity. All five ponds filled to a depth of 200-300 mm. Visual Water Quality – Turbid from steep batter run off but likely to settle once rain ceases.	16th January 2019 Pond 2 contained 50 mm of water. Remaining four ponds were dry. Visual Water Quality – Similar to surrounding area. Still slightly turbid but considered suitable for tadpoles.	5th February 2019 All ponds dry. Visual Water Quality – Dry.	Newly constructed ponds functioning in a manner more consistent with the Threatened Frog Management Plan – adequate size, not filling with as much sediment and drying at varying rates. Follow up rainfall considered essential for ponds to retain water for more than 30 consecutive days.
Halfway Creek	19100 West	4	18th December 2018 All ponds filled to capacity. Contain 200-350 mm of water. Visual Water Quality – same as adjacent flooded areas to the south with a slight tannin stain.	16th January 2019 Ponds have dried out. Visual Water Quality – Dry.	5th February 2018 Ponds dry and have been so for some time. Visual Water Quality – Dry.	Follow up rainfall required every 10-14 days to ensure ponds retain water for more than 30 consecutive days. Ponds drying out too quickly and require intervention to retard draining.
Bald Knob Tick Gate Road	25000 East	5	18th December 2018 All ponds filled to capacity. Contain 250-350 mm of water. Visual Water Quality – same as adjacent flooded areas – turbid from surrounding sodic soils.	16th January 2019 Pond 3 contained 75 mm of water. Remaining four ponds were dry. Visual Water Quality – Similar to surrounding area. Still turbid but considered suitable for tadpoles.	5th February 2018 Ponds dry and have been so for some time. Visual Water Quality – Dry.	First year of monitoring. Frogs selected a disused borrow pit 30 m away for breeding during this year. Different drying times is consistent with the design intentions outlined in the Threatened Frog Management Plan.
Section 3	No compensatory ponds constructed to date					No compensatory ponds constructed to date
Section 6	No compensatory ponds constructed to date					No compensatory ponds constructed to date
Section 7	No compensatory ponds constructed to date					No compensatory ponds constructed to date

5.3.6 Connectivity Structure Monitoring

Green-thighed Frogs were recorded within 100 m of structures at three locations during this round of monitoring (Table 5-3). At ch. 24570 (Site 3A), one female was captured and toe clipped from the eastern side of the newly operational south bound carriageway. At this location the north bound carriageway remains without frog fencing. Further north near Franklins Road, a male frog was captured and marked at ch. 27420 around 50 m from the box culvert. This structure currently provides habitat connectivity for the south bound carriageway. At Six Mile Lane, three frogs were captured as part of structure monitoring for ch. 37330 and include two female frogs from the eastern side of the carriageway whilst a male was captured and marked from the western side of the carriageway. At the remaining four sites, no frogs were captured within 100 m of the nominated structure.

Table 5-3. Summary of connectivity structure monitoring performed during Year 4 at Sites 1-5 and for Year 3 at Sites 6-10.

Chainage	Structure Type	Length / specs	Frog Fence	Number of Green-thighed Frogs (toe-clip) Left hand is east side. Right hand is west side.	Comments
19180	RCBC	3.0 x 3.0 x 50 m	1900 to 19400 (400 m)	No captures	Culvert tends to flood during rainfall periods that are suitable for Green-thighed Frog breeding
24570	RCBC	3.0 x 3.0 x 23 m	24500 to 25000 (500 m)	1 x Female (left hand outer finger)	Culvert only services south bond lanes and provides limited habitat connectivity
27420	RCBC	3.0 x 3.0 x 40 m	27420 to 28000 (580 m)	1 x Male (left hand outer finger)	Culvert only services south bond lanes and provides limited habitat connectivity

5.3.5 Frog Fencing

No Green-thighed Frogs were recorded on the road side of the installed permanent fencing (Table 5-4). Some other species of frog were recorded on the road side of the fenced sections and include both tree frogs (i.e. hylids) and ground dwelling frogs (i.e. myobatrachids). At Halfway Creek (Site 2A), the road side table drain tends to attract frogs to the carriageway and many tens of frogs had found a way through or over the frog fence. At Site 4A (ch.26200), the continued use of the Old Pacific Highway as the north bound carriageway during this round of monitoring makes the frog fence redundant and offers no real protection. It is noted that the new north bound carriageway will be under construction as part of Year 5 monitoring.

Table 5-4. Summary of permanent frog exclusion fence monitoring during Year 4 at Sites 1-5.

Site	Ch. + Side of Carriageway	Status of Fencing	Fencing Extent Surveyed	Green-thighed Frogs Within 2 m Habitat Side of Fence	Frogs on Road Side of Fence	Comments
Redbank Creek	5600 East	Completed permanent fence	5500-5625	Nil	Nil	Some minor breaches and finishing attention at tie in points to culvert and directional changes required. Majority of other frog species found on habitat side indicating frog fence is effective at reducing but not preventing frog movements onto the carriageway.
Falconers	11800 West	Completed permanent fence	11700-11850	Nil	Nil	Steep batter associated with this area probably improves the functionality of the fence.
Halfway Creek	19100 West	Completed permanent fence	19000-19500	Nil	Nil	Deep table drain on road side appears to attract frog fauna. Number of breach points at turn points and ties to culvert areas.
Bald Knob Tick Gate Road	25000 East	Completed permanent fence	24500-25000	Nil	Nil	First time fence area has been surveyed in conjunction with newly constructed ponds.
Old Highway Heavy Vehicle Checking Station	26200 West	Completed permanent fence	26100-26250	Nil	Nil	The continued use of the Old Pacific Highway for north bound carriageway has rendered the frog fence as ineffective with live traffic on either side of the fence.
Franklins Road	28000 East	Completed permanent fence	27900-28050	Nil	Nil	Some minor breach points in the fence but considered effective at reducing frog movements out onto the carriageway. Access road with grid that still enables frogs to access roadway

5.4 Discussion

Green-thighed Frog monitoring over the 2018/2019 season has continued to result in frogs being detected at most but not all of the monitoring sites. Frogs are proving difficult to detect at Falconers (Site 1A), Halfway Creek (Site 2A) Glenugie Old Heavy Vehicle Checking Station (Site 4A) and Tabbimoble (Site 10A). Apart from Site 4A, the previously identified breeding sites have been removed to accommodate the new carriageway. Some more extensive surveys may be required in the near future to determine where the alternative breeding sites of these displaced frogs are now located. The fact that these past few seasons have become increasingly dry with below average rainfall also suggest that natural fluctuations also play a part in the current results. This would explain the difficulties associated with detecting frogs at some of the reference or control sites with no frogs found in Yuraygir State Conservation Area (Site 2B) and Pine Brush State Forest (Site 8B) again.

Sites 3A (Bald Knob Tick Gate Road), 4B (Glenugie East), 5A (Franklins Road), 5B (Bom Bom State Forest), 6B (Airport Road), 7A (Six Mile Lane) and 7B (Glenugie East) all recorded frogs in and around breeding sites, although not always around the constructed compensatory breeding ponds (Site 3A). The numbers of frogs heard and observed was encouraging to suggest a successful breeding event during this season, however, the proceeding 30 days of little to no rainfall combined with high daytime temperatures meant that most of the breeding sites dried out. This resulted in what appears to be a failed breeding event across the southern breeding sites. Further north at Sites 9 and 10, water had remained at some of the monitored depressions indicating there may have been some limited breeding success, just not at the monitored ponds where no tadpoles, metamorphs or juveniles were found. Breeding events in late spring and throughout the summer months of December and January appear heavily influenced by follow up rainfall, something that did not occur in early 2019.

The constructed breeding ponds were found to mimic those of the naturally occurring depressions at other monitoring sites. Compensatory ponds at Redbank Creek, Falconers and Bald Knob Tick Gate Road dried at varying rates and importantly, there was at least one pond with some water during the post breeding surveys performed in January 2019 (Plate 5-3 to 5-5. The ponds at Halfway Creek (ch. 19180) dry too quickly without regular follow up rainfall and require some form of intervention (i.e. bentonite lining) if they are going to meet the design intention of holding water for at least 40-50 days. The corrective actions applied at Falconers (ch. 11800) and Bald Knob Tick Gate Road (ch. 25000) appear to have addressed the problems outlined in previous monitoring reports so no further remediation is required at this point in time.

For the remaining sites, the locations of compensatory ponds are yet to be determined and this will need to be addressed in the near future to ensure the commitments of the plan are met whilst ensuring important breeding habitat removed to accommodate the Upgrade has been adequately compensated. Without it, populations may decline at sites along Sections 3, 6 and 7 of the Upgrade.

How the data collected for Year 3 and 4 compares or performs against the prescriptions outlined in the Threatened Frog Management Plan is outlined in the following section.

5.5 Performance Measures and Corrective Actions

A series of performance indicators and corrective actions have been outlined in Section 7.2.3 of the Threatened Frog Species Management Plan (RMS 2015). This plan states that *should it become clear that sites that were occupied prior to road construction (i.e. established impact monitoring sites) have become unoccupied, or abundance (estimated using the transect counts) has declined beyond the identified thresholds (i.e. 25%) relative to control/reference sites, corrective actions must be implemented in accordance with those provided in Table 7-1.*

Monitoring during the 2018/19 season includes the population monitoring component as well as some of the compensatory ponds at some but not all of the sites. Underpass structure monitoring and permanent frog fence monitoring also forms part of the performance related monitoring where structures and permanent frog fencing has been completed.

The performing factor for the population monitoring is the number of male frogs recorded during the Stage 1 survey, although recommendations in Lewis (2017) have allowed for this to be updated to the number of frogs recorded. The recorded declines and absences in Year 4 reflect the variability in survey conditions other than any real decline and could be considered natural variation (Table 5-5). For example, there is an equal number of impact and reference sites where the frogs were absent in 2018/19. Only additional monitoring could verify this.

Surveys performed at three of the connectivity structures where frogs were recorded at two of these with two captures in total (Table 5-5). Monitoring during successive years will provide an opportunity for their recapture and assessment as to whether these frogs have moved across the carriageway. Permanent frog fence survey tied into this connectivity found no frogs on the carriageway side of the fence, although a number of potential breach points were observed (Plate 5-6).

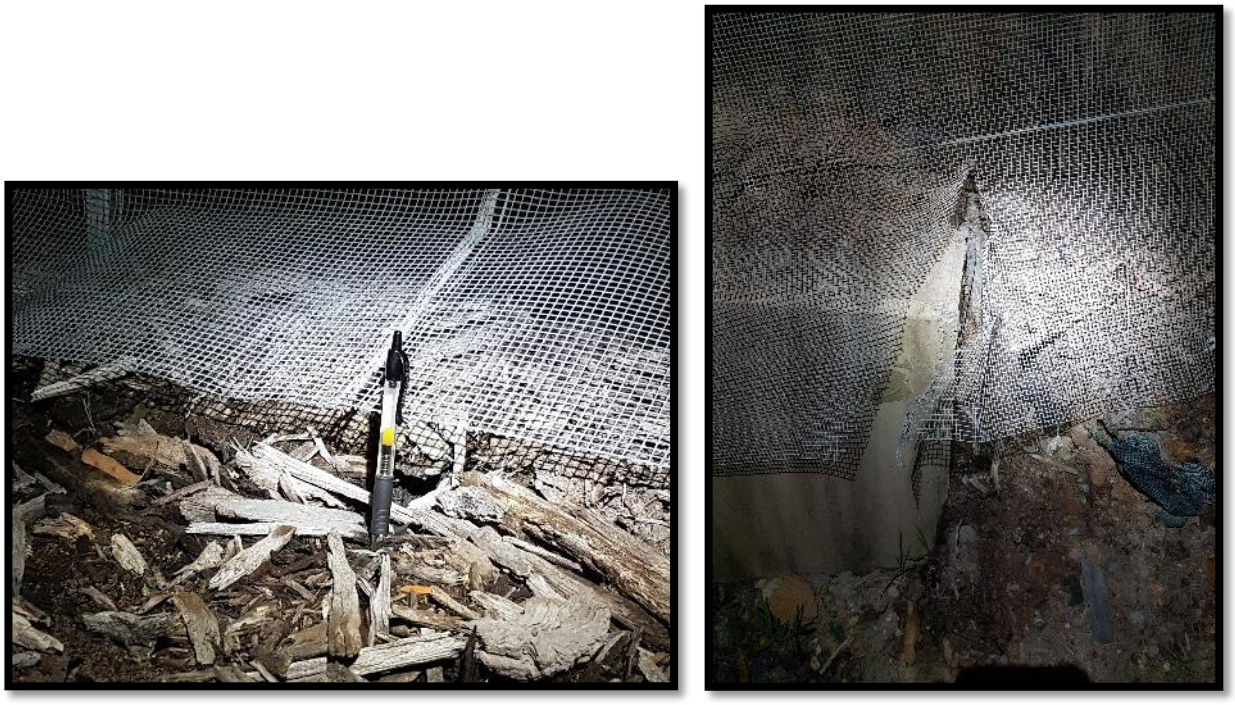

Plate 5-6. Commonly encountered breach ponds along section of Green-thighed Frog permanent frog fence.

In regard to the compensatory ponds, there was no recorded use at Redbank Creek, Falconers and Halfway Creek, ponds that have been installed and monitored now for 3 years. Falconers has received some remediation works so some further monitoring is required before an assessment can be made on its overall suitability as a compensatory pond site. Ponds were constructed in late winter 2018 at Bald Knob Tick Gate Road and monitored for first time where no frogs were recorded. The ponds at halfway Creek dry too quickly to be considered reliable breeding habitat for Green-thighed Frog. A bentonite application could slow the drying process and improve the ponds overall suitability. No ponds have been constructed in Sections 3-7 yet commitments identified in TFMP state "*where breeding habitat will be directly impacted by the project or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*". As the ponds nor monitoring sites occur in riparian areas, the riparian habitat revegetation parameters appear irrelevant at this time.

Table 5-5. Performance indicators and corrective actions from the Threatened Frog Species Management Plan (RMS 2015).

Triggers for corrective actions	Corrective actions	Relevance to 2018/19 Green-thighed Frog Monitoring	Results of 2018/19 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
Population Monitoring					
The absence of threatened frogs at impact sites identified as occupied in the baseline monitoring surveys. A relative decline in abundance of 25% or more at an impact site than its relative control site over 3 consecutive monitoring periods. Frog abundance determined by standardised transect counts: • Number of Wallum Sedge Frogs per 100 m2 of habitat; • Number of Giant Barred Frogs per 500 m of habitat; • Number of adult male Green-thighed Frogs per Stage 1 survey (breeding survey) (as outlined in Section 4.3).	Review monitoring methods immediately, considering further monitoring and assessment if there is a decline in population abundance. Investigate effectiveness of frog exclusion fencing immediately. Closely monitor habitat conditions over a period of three months to ensure they are suitable, in particular hydrology (hydro-period), water quality and vegetation. Assess the requirement for additional offsets where a threatened frog population is no longer present in a previously occupied area, and this habitat is deemed unsuitable for the target species.	Relevant	Green-thighed Frogs recorded from impact sites of 3A, 5A, 7A, 8A and 9A and from reference sites 4B, 5B, 6B, 7B, 9B and 10B. Green-thighed Frogs absent from impact sites of 1A, 2A, and 10A, and control sites 1B, 2B and 8B. The recorded declines and absences reflect the variability in survey conditions other than any real decline and could be considered natural variation. For example, there is an equal number of impact and reference sites where the frogs were absent in 2018/19.	Variability in results influenced by prevailing weather conditions at the time of sampling.	Only additional monitoring could assist in confirming detection at Sites were frogs remain absent.
Underpass Structure Monitoring					
The use of the structure by less than 1% of the estimated population size. Connectivity structures not maintained (i.e. culverts clogged with debris or sedimentation). Frog exclusion fencing damaged or ineffective.	Review monitoring methods where goals are not achieved, by increasing frequency, intensity and duration, to ensure individuals are identified. Survey habitat adjoining the connectivity structures and undertake Landscape improvement (planting, weed removal) to improve habitat functionality. Survey and monitor crossing structures and frog fencing to ensure they are functional (i.e. are adequately maintained, including fencing is not	Relevant	Surveys performed at three of the connectivity structures. Frogs captured and marked at: * ch. 24570 (Site 3A), one female - eastern side *ch. 27420 (Site 5A), one male – eastern side	Commencement of mark recapture works to be assessed in following years.	Nil

Triggers for corrective actions	Corrective actions	Relevance to 2018/19 Green-thighed Frog Monitoring	Results of 2018/19 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
	damaged, and connectivity structure is operating correctly). Monitor twice per year. Assess the need for offsets if connectivity structures are identified as ineffective over three consecutive monitoring periods.				
Constructed Pond Monitoring					
Absence of threatened frogs and metamorphs at the compensatory ponds after three years since construction.	Investigation be undertaken to determine why there may be a lack of success and, as where recommended, changes be made to the habitat and monitored for effectiveness (i.e. 3 more years of monitoring) Review monitoring methods, considering timing and weather conditions to ensure individuals are identified. Review location of the compensatory pond and consider moving, and/or modifying or constructing additional ponds. Investigate habitat adjoining the upgraded highway and consider improving habitat condition and connectivity.	Three rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over three seasons at three sites and one season at Site 3A. At Sites 6-10 no ponds have been constructed to date.	No use recorded at Redbank Creek, Falconers and Halfway Creek. Ponds were constructed in late winter 2018 at Bald Knob Tick Gate Road and monitored for first time where no frogs were recorded. No ponds constructed in Sections 3-7 yet commitments identified in TFMP.	Frogs have been recorded to the west of the carriageway at Redbank Creek whilst ponds located on eastern side. Frogs known from 600 m to the north. May be other suitable locations for breeding nearby but access constraints prevent surveys through much of this area. Ponds at Falconers had silted up and no longer provide frog breeding habitat. Addressed in late winter 2018 and now considered functional. Ponds at Halfway Creek dry too quickly without regular follow up rain. Could be partly addressed via a bentonite application to slow drainage. Ponds not constructed at Bald Knob Tick Gate Road (ch. 25000). Although no compensatory ponds were constructed at Franklins Road (ch. 28000) there is probably sufficient retained breeding habitat.	1. Halfway Creek ponds 19180 - corrective action point 3 “modify” via the use of bentonite to reduce drying time of ponds. 2. Construct ponds in Section 3 so that monitoring can commence in those areas where breeding habitat has been removed (i.e. Section 3, 7).
Water pH exceeds 5.5 for Wallum Sedge Frog	Investigate ways to reduce pH of water.	Not Applicable	Not Applicable	Not Applicable	Not Applicable
Visual water quality of the compensatory pond is not similar to nearby unimpacted and/or similar	Complete site specific investigation to identify the causes of the unsuitable hydrological conditions or water quality.	Relevant	Water quality at all ponds is comparable to surrounding habitat, often turbid from sodic soils.	Comparable to surrounding habitat.	Nil

Triggers for corrective actions	Corrective actions	Relevance to 2018/19 Green-thighed Frog Monitoring	Results of 2018/19 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
wetlands or is unsuitable for frog occupation.					
No persistent water present in ponds (negative hydro period) despite recent rainfall.	Assess possible causes for water draining from the pond and apply physical corrective actions	Three rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over three seasons at three sites and one season at Site 3A. At Sites 6-10 no ponds have been constructed to date.	Some water retained at Redbank Creek, Falconers and Bald Knob Tick Gate Road but not Halfway Creek (ch.19180). No ponds constructed in Sections 3-7 yet commitments identified in TFMP.	Sandy soils at Halfway Creek equate to shorter drier periods. Proximity of services and the project boundary limit the extent and location of ponds.	1. Halfway Creek ponds ch.19180 - corrective action "apply physical corrective actions" via the use of bentonite to reduce drying time of ponds.
Mosquito Fish present and threatened frogs / tadpoles absent.	Draining pond to remove Mosquito Fish and allow pond fill at the next rain event.	Three rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over three seasons at three sites and one season at Site 3A. At Sites 6-10 no ponds have been constructed to date.	No Mosquito Fish recorded.	Ponds are drying out to ensure they remain fish free.	Nil.
Constructed habitat un-suitable for frogs (e.g. wetlands have un-suitable hydro-period (as determined from monitoring events), water quality or associated vegetation) as detailed in section 5.4.4.	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Three rounds of monitoring have been completed at Sections 1 and 2 where ponds have been constructed at four sites and monitoring performed over three seasons at	1. Ponds at Redbank Creek, Falconers and Bald Knob Tick Gate Road functioning as suitable frog breeding habitat. 2. Ponds at Halfway Creek drying too quickly and require rectification	At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services whilst the project boundary is in close proximity.	1. Add bentonite or some similar product to retard drying times so they accord more with larval development of Green-thighed Frog of 40-50 days.

Triggers for corrective actions	Corrective actions	Relevance to 2018/19 Green-thighed Frog Monitoring	Results of 2018/19 Green-thighed Frog Monitoring	Potential Contributing Factors	Corrective Action Required
		three sites and one season at Site 3A. At Sites 6-10 no ponds have been constructed to date.	works. The longitudinal table drain beside carriageway has increased drainage in this area and requires compensatory measures for Green-thighed Frog.		
Revegetated native habitat in poor condition (e.g. >30% cover died, plant dieback).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Not relevant.	Not Applicable	Not Applicable	Not Applicable
Frog absence confirmed following monitoring surveys (it should be noted that a pond may be suitable for frogs, but not colonised).	Undertake revegetation maintenance, i.e. replanting, erosion control, weed control. Ensure wetlands are functioning as designed and present suitable habitat in terms of water quality and hydro-period.	Relevant	Redbank Creek, Falconers and Bald Knob Tick Gate Road – ponds are constructed in a suitable manner and considered functional. Halfway Creek – Ponds dry out too quickly.	At Halfway Creek, longitudinal drains act as a sump to the surrounding area and increased drying times. Difficult area to position ponds away from other infrastructure and services combined with close proximity of the project boundary.	Halfway Creek - add Bentonite or some similar product to retard drying times so they accord more with larval development of Green-thighed Frog of 40-50 days.
Riparian Habitat Revegetation					
Greater than 10% of riparian plants have died after first 12 months of maintenance. Greater than 20% of riparian plants have died after three years of maintenance. Total weed coverage is more than 30% in revegetation areas. Bank erosion causes unforeseen revegetation area instability.	Review maintenance schedule for revegetated areas immediately after trigger. Replace dead plants within one month of issue being identified. Increase weed control if required as soon as practicable or review control methods being used. Install physical measures to halt bank erosion within one month of issue being identified.	Not relevant – locations are not within riparian zones.	Not relevant	Not relevant	Not relevant

5.6 Conclusions and Recommendations

Monitoring for the Green-thighed Frog was triggered by heavy rainfall in mid December 2018 for most of the sites located between Corindi and Tyndale. As this rainfall was triggered by localised thunderstorms to the east and south of Grafton, it did not reach the northern sites located around Jackybulbin and New Italy which had to wait until mid-autumn when sufficient rain fell as part of a broader weather system. This resulted in a drawn out post breeding survey regime with surveys in January and February 2019 for the southern sites, and mid May 2019 for the northern sites.

Frogs were recorded at 12 of the monitoring sites including five impact sites and included some encouraging numbers of frogs from Site 3A (Bald Knob Tick Gate Road), 5A (Franklins Road), 5B (Bom Bom State Forest), 6B (Airport Road) and sites over in Glenugie East (4B, 7B). There was a notable absence of frogs from the southern monitoring sites of Falconers (1A), Halfway Creek (2A) and their adjacent reference sites. The same situation remains at Site 4A (Old Southbound Heavy Vehicle Checking Station) in Glenugie State Forest where the reuse strategy of the old carriageway has created a monitoring site between the north and southbound lanes. Frogs are unlikely to return to this site. Further north, frogs remain absent at Site 10 A (Tabbimoble North) where construction has removed the previously monitored breeding site and an adjacent ephemeral gully now forms the focal point for surveys.

Monitoring of the constructed compensatory frog ponds continues to find no evidence of Green-thighed Frogs using any of the ponds at Redbank Creek, Falconers, Halfway Creek or Bald Knob Tick Gate Road. Based on design principals of water retention, variability in drying times and the adequacy of calling points they do appear functional and it may take a return to average or above average rain for frogs to be recorded using them. This includes the ponds at Falconers where rectification works had taken place in winter 2018 now that the carriageway batters have stabilised and sediment flows have reduced. At Halfway Creek, the previously reported problem of the ponds drying too quickly still exists and this requires attention now that three consecutive monitoring periods have recorded no frogs and ponds drying too quickly for tadpoles to reach metamorphosis. The longitudinal drains constructed to move water away from the carriageway have reduced the time water ponds in this area and with this we may see broader change to the surrounding plant community types. The application of bentonite or some other similar product is a recommended corrective action at this location.

The performance indicators of the monitoring program were updated to reflect the actual number of frogs recorded rather than relying on the numbers of calling males (*see* Lewis 2017). Although the relative decline in abundance has not exceeded 25%, there are some reported declines but these tend to be consistent with the nearby reference sites. For example, frogs are currently absent at both of the Site 1 and Site 2 treatments.

Monitoring of the installed permanent frog fencing indicates Green-thighed Frogs remain on the habitat side of the fence. Although other types of frogs were found on the carriageway side of the fence, many more were found on the habitat side. Addressing the reported breaches outlined in this report would improve the effectiveness of reducing frog movements onto the carriageway, but is unlikely to entirely eliminate it.

Monitoring of the connectivity structures found frogs in the vicinity of two of the three structures. As this was the first season of mark recapture techniques, their overall effectiveness of restoring habitat connectivity will be assessed in Year 5 in Section 1 and 2 and is yet to commence in Section 3-7 of the Upgrade.

Based on the 2018/19 findings, the following recommendations and Transport for NSW responses have been presented in Table 5-6.

Table 5-6. Recommendations following 2018/19 Green-thighed Frog monitoring and Transport for NSW responses.

Recommendation No	Recommendation	Transport for NSW
1.	Bentonite or similar additive applied to compensatory ponds at Halfway Creek (ch. 19180).	Adopted - TfNSW will explore options to increase water retention.
2.	Transport for NSW inspect fences for reported breach points at Site 2A, 3A, 5A, 8A, 9A and 10A.	Adopted - TfNSW will review locations that present road kill risk to Green-thighed Frog.
3	The compensatory Green-thighed Frog breeding ponds be identified in Sections 3-8. The TFMP currently notes "*These will be constructed where breeding habitat will be directly impacted by the project (Figure 3-1 and Figure 3-3) or changed hydrological patterns have the potential to affect the suitability of breeding habitat areas adjacent to the corridor*".	Noted - Compensatory ponds will installed in accordance with the Threatened Frog Management Plan.

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7.0 APPENDIX A – RAW FROG SURVEY AND RAINFALL DATA

Table A1. Raw Year 4 Giant Barred Frog survey data.

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	108	175	00073567C6	90 M DOWNSTREAM	5	Second time	Observed	Above litter	Downstream of bridge on southern bank. Location GPS		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	105	170	000735367D	150 m Downstream	8	First Time	Observed	Above litter	Downstream on southern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Male	Adult	No Colour	70	50	000735C0EE	150 M DOWNSTREAM	3	Second time	Observed	Among Lomandra	Downstream on southern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	103	135	000735B20F	100m upstream	7	Second time	Observed	On Exposed Tree Roots	Upstream on northern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Male	Adult	Light colour	74	60	000735A0AF	50 m upstream	4	Second time	Observed	Bare ground	Upstream on northern bank		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Female	Adult	Not gravid	113	130	MISSING FRONT LEFT LEG	20m -ds	3	Second time	Observed	Above Litter	Missing entire left leg. Was tagged but tag number not recorded. Whoops.		
1A	Corindi Creek	7/11/2017	2040	2317	18	16	40	74	0	1	shallow, little water trickling in some spots	11	Unknown	Sub Adult	Immature	53	19	00073567T9	40 m -ds	5	First Time	Observed	Above litter	Downstream on southern bank		
												Missed 4 *M. iteratus* - 2 upstream 2 downstream on north bank														
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	dark grey	78	73	7352C37	70 m - us	2	First Time	Heard	Above litter	Northern side	517552	6678574
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	dark brown	73	53	735bec7	100 m - us	3	Second/third Time	Observed	Above litter	Northern side	517518	6678570
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	pale brown	81	77	7357972	180m - us	1	Second/third Time	Observed	Above litter	Northern side	517498	6678597
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Male	Adult	pale grey	79	56	73585AD	190m -us	3	First Time	Observed	Above litter	Northern side	517506	6678605
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	80	52	73529a0	190m -us	5	First Time	Observed	Above litter	Northern side	517516	6678601
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	110	144	7356F45	180m - us	9	Second/third Time	Observed	Above litter	Southern Side	517467	6678544
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	gravid	111	170	7352A54	70m - us	0	Second/third Time	Observed	Water's Edge	Southern Side	517527	6678552
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	gravid	110	173	735AFD5	220 m -ds	5	First Time	Observed	On Bare Ground	Southern Side	517837	6678477
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	82	75	735D21b	80m - ds	4	First Time	Observed	Above litter	Northern side	517750	6678572
1A	Corindi Creek	7/02/2014	2:20	5:35	20		0	75	1	0	shallow, little water trickling in some spots	13	Female	Adult	ng	113	135	MISSING FRONT LEFT LEG	20m -ds	1	First Time	Observed	Above litter	Northern side	517672	6678613
		Missed 3 M. iteratus. 2x SS DS, 1x SS US										Missed 3 M. iteratus. 2x SS DS, 1x SS US													
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Male	Adult	Moderate nuptials	78	53	000735C609	400m -DS	5	Second time	Observed	On sand	Southern bank - suspect recapture from RH 3rd Digit meaning captured three times to date		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	55	22	000735C476	200m -DS	4	First time	Observed on litter	Above litter	Northern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	65	35	000735C453	175m -DS	4	Second time	Observed	Part buried sand and litter on	Southern bank. Previously captured as a sub adult during Year 2		

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing
																							scoured bank			
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	99	120	000735C1DE	20m - DS	8	Second time	Observed	On rock	Southern bank Left Hand 3rd finger - Captured in Year 2 at top of the transect		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	49	16	000735C488	150m-DS	5	First time	Observed	On sand	Southern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Male	Adult	Light Nuptials	76	50	00073535EB	70m - DS	3	Second time	Observed	Above litter	Southern Bank - captured during Year 2 in similar area		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	94	80	000735ACDB	20 m - DS	14	Second time	Observed	Above litter	Southern Bank - second time captured from Year 2		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub Adult	Immature	48	16	0073539FD	50 m - DS	4	First time	Observed	Above litter	Northern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	77	47	000735B047	250m - DS	8	Second time	Observed	Above litter	Northern bank - captured during Year 2 monitoring		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Not gravid	90	98	000735AE73	350 m downstream	8	Second time	Observed	Above litter	Northern bank - captured in same general area during Year 2		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Male	Adult	Moderate nuptials	75	54	00735C2FD	160 m - DS	5	First time	Observed	Above litter	Southern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Unknown	Sub adult	Immature	57	120	00735C611	450m - DS	4	First time	Observed	Above litter	Southern bank		
1B	Madmans Ck	8/11/2017	9	314	16	14	50	81	0	1		15	Female	Adult	Part Gravid	100	120	0007359BDC	350 m - DS	4	Second time	Observed	Above litter	Northern bank - second time capture from Year 2		
												Missed two M. iteratus - both Sub adult sized														
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	48	9	7358CB6	DS	10	First Time	Observed	Above litter		nd	nd
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Moderate nuptials	78	45	735B3EA	DS	1	First Time	Heard	Above litter		nd	nd
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Light Nuptials	74	51.1	7359F9C	DS	1	First Time	Observed	Above litter		510937	6673721
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Dark nuptials	85	65	73535eb	DS	2	Recapture	Heard	Above litter		510937	6673721
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Juvenile	Immature	38	8.5	735978a	DS	4	First Time	Observed	Above litter		510937	6673688
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	40	8	7357f63	ds		First Time	Observed	Above litter		510976	6673704
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	45	5	7355468	ds	6	First Time	Observed	Above litter		511078	6673827
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Dark nuptials	80	60	735BCF7	ds	2.5	Recapture	Heard	Above litter		511064	6673850
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Male	Adult	Dark nuptials	85	76	7352c0a	240m - DS	1.5	Recapture	Heard	Above litter		511055	6673823
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	83	68.5	73586A5	260m -DS	10	First Time	Observed	Above litter		511030	6673843
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	79	55	735bd31	260m -DS	8	First Time	Observed	Above litter		511030	6673843
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	84	60	735A413	300m -DS	0.5	First Time	Observed	Above litter		511024	6673889
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	46	8	7359 e 30	390m -DS	2	First Time	Observed	Above litter		511024	6673889
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	49	10	735b1bc	300m - DS	2	First Time	Observed	Above litter		511041	6673893
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Gravid	102	136	735A2C7	350m - DS	2	First Time	Observed	Above litter		510999	6673920
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Gravid	112	158.5	735b6f6	500m - DS	2	First Time	Observed	Above litter		511077	6674022
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Unknown	Sub Adult	Immature	56	18	7357802	450m - DS	5	First Time	Observed	Above litter		510988	6674011
1B	Madmans Ck	6/02/2014	20:20	12:40	19	17	100	60	0	0	shallow, no water running	19	Female	Adult	Not gravid	112	138	73555c2	30m -DS	6	First Time	Observed	Above litter		510900	6673658
												Missed 1 Adult iteratus														
2A	Dirty Creek	10/11/2017	1958	2147	22	16	50	72	0	0		0														
2A	Dirty Creek	5/02/2018	2335	145	21	17	100	83	0	1		0														
2B	Pigeon Gully	10/11/2017	2221	7	17	14	40	86	0	0		0														

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
2B	Pigeon Gully	5/02/2018	2040	2220	19	17	100	85	0	1		0															
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Light nuptials	65	13	000735C3E3	120m-DS	9	Second time recapture from Year 2	Observed	Above litter	Northern bank	Originally tagged as a sub adult in Year 2 so its Year adult male		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	48	13.5	000735CF3H	120m -DS	6	First time	Observed	On sand	Northern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	49	12.5	000735BD8D	100m -DS	4	First time	Observed	On sand	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	47	17.5	0007358D8F	120m - DS	4	First time	Observed	Above litter at base of Lomandra	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	50	16	00073579D3	90m- DS	3	First time	Observed	On sand of scoured bank	Edge of powerline easement - Northern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	45	13	000735876C	50 m downstream	4	First time	Observed	Above litter on scoured bank	Northern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Very Dark Nuptials	74	46	000735B008	construction site	3	Second time	Observed	On sand	Northern bank	Recapture from similar area during Year 2		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Male	Adult	Dark Nuptial	81	65	000735CB6F	30m -US	4	Fourth time recapture	Observed	Above litter	Southern bank	Appears to be a dominate male frog recaptured for the fourth time		
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	53	17	000735CF3D	40m - US	5	First time	Observed	Above litter	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	46	11.5	0007352C9F	10m -US	2	First time	Observed	On bare bank	Southern bank			
3A	Halfway Creek	10/11/2017	2045	2358	21.5	17	65	79	0	1		16	Unknown	Sub adult	Immature	50	16	0007356376	100m - US	5	First time	Observed	Above litter	Southern bank			
												3 sub adults and 2 adults missed															
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Juvenile	Immature	37	4	735AE69	40m - DS	1	First time	Observed	Above litter	Southern bank	506519	6690536	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	82	64	735841E	30m - DS	2	Recapture	Heard	Part buried in litter and sand	Northern bank	506528	6690533	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	48	47	735c72B	70m - DS	1	First time	Observed	Above litter	Northern bank	506509	6690554	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	82	47	735c02C	90m - DS	1	First time	Observed	Above litter	Northern bank	506492	6690654	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	51	13	73593ED	90m - DS	3	First time	Observed	Above litter	Northern bank	506495	6690567	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	98	60	735b8F8	90m - DS	4	First time	Observed	Above litter	Northern bank	506495	6690567	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Unknown	Sub Adult	Immature	46	8	735A512	180m - DS	1.5	First time	Observed	Above litter	Southern bank	506412	6690540	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	81	54	7358DEB	120m -DS	3	First time	Observed	Above litter	Southern bank	506455	6690551	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	80	50	735C00A	50m -DS	10	First time	Observed	Above litter	Southern bank	506477	6690548	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle.	19	Female	Sub Adult	Immature	50	13	7355AB6	50m - DS	2	First time	Observed	On sand	Southern bank	506520	6690526	

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
											Some ponds stagnant																
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	78	52	7353DFE	65m - US	1	First time	Heard	On sand	Northern bank	506635	6690514	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	74	46	7359648	70m - US	0	First time	Heard	on water's edge	Northern bank	506639	6690515	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Light Nuptials	83	46	735A52f	70m -US	2	First time	Heard	on log	Northern bank	506663	6690520	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Dark Nuptials	72	41	7352F38	105m -US	4	First time	Observed	Above litter	Southern bank	506714	6690505	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Gravid	118	144	7353 e 11	200m -US	3	First time	Observed	under litter	Southern bank	506826	6690470	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Juvenile	Sub Adult	Immature	46	8.5	73586AB	115m-US	3.5	First time	Observed	Above litter	Southern bank	506749	6690502	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Female	Adult	Not gravid	60	17	735629b	80m-US	3	First time	Observed	on moss	Northern bank	506701	6690507	
3A	Halfway Creek	8/02/2014	12:15	4:35	20		100	85	0	0	Very shallow, gentle trickle. Some ponds stagnant	19	Male	Adult	Dark nuptials	75	38	735B701	80m-US	3	First time	Heard	Above litter	Northern bank	506701	6690507	
												1 adult male heard calling but not often enough to be located															
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate nuptials	82	58	0007357E1B	30m - DS	5	Second time	Observed	Above litter	Northern bank	Recapture from Year 2		
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate Nuptials	75	47	0007352FFD	50m - DS	4	First time	Observed	Above litter	Northern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Light nuptials	73	55	00073577DF	120m - DS	3	First time	Observed	Above litter	Southern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Dark nuptials	80	46	0007352CCF	190m - DS	6	First time	Observed	On log	Southern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Unknown	Sub adult	Immature	52	19	0007358F95	190m - DS	5	First time	Observed	Above litter	Southern bank			
3B	Yellow Crossing Road (Wooli	11/11/2017	28	0340	17	17	60	83	0	1		12	Female	Adult	Not gravid	104	120	000735C4BF	220m - DS	7	Second time	Observed	Above litter	Northern bank			

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
	River Catchment)																										
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Light nuptials	74	55	0007358C90	100m - DS	5	First time	Observed	Above litter	Southern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Female	Adult	Not Gravid	93	88	0007359C55	15 m - US	8	First time	Observed	Above litter	Northern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Male	Adult	Moderate Nuptials	74	48	0007358944	40 m - US	5	First time	Observed	Above litter	Northern bank			
3B	Yellow Crossing Road (Wooli River Catchment)	11/11/2017	28	0340	17	17	60	83	0	1		12	Unknown	Sub adult	Immature	50	18	0007357CB3	100m -US	5	First time	Observed	Above litter	Southern bank			
												2 sub adults missed															
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	47	7.5	7356534	30m - US	5	First time	Observed	Above litter		515423	6689075	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Gravid	110	159	7359AFD	150m - US	5	First time	Observed	Above litter		515325	6689070	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Not Gravid	101	124	73530f8	220m -US	2	First time	Observed	Above litter		515300	6689097	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Female	Adult	Not Gravid	80	50	735BAFD	230m - US	4	First time	Observed	Above litter		515300	6689093	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	42	7	735b50e	50m - US	5	First time	Observed	Above litter		515390	6689088	
3B	Yellow Crossing Road (Wooli River Catchment)	7/02/2014	20:15	23:20	20		100	85	0	0	mainly dry, some small pools	7	Unknown	Sub adult	Immature	48	8	735967f	30m - US	3	First time	Observed	Above litter		515411	6689083	
												1 male calling upstream could not be located															
4A	Boneys Creek	14/11/2017	2113	2255	21	17	40	77	0	1	Series of pools	1	Unknown	Sub Adult	Immature	52	16	0007357BF9	60 m downstream of construction works	5	First time	Observed	Above litter	Southern bank			

BACI Monitoring Site	Site	Sample Date	Start Time	Finish Time	Mean Air Temperature oC	Mean Water Temperature oC	Mean Cloud Cover (%)	Mean Humidity (%)	Mean Wind (0-4)	Mean Rainfall (0-3)	Stream Depth (Description)	Giant Barred Frogs	Sex	Age Class	Reproductive Status/Age Class	Length (mm SV)	Weight (g)	PIT Tag Ref Number	Zone	Distance to Water (m)	Last Known Recapture Point	Activity at Time of Capture	Microhabitat	Notes/Comments	Easting	Northing	
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Male	Adult	Moderate nuptials	71	42	735C0E1	10m - DS	0.5	First time	Heard	in grass		512478	6686214	
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Female	Adult	Gravid	115	166	735B4E9	210m - DS	10	First time	Observed	Above litter		512445	6686351	
4A	Boney's Creek	8/02/2014	23:00	2:00	20	17	0	90	0	0	Shallow, little water movement.	3	Female	Adult	Not gravid	101	124	73587CC	190m - DS	5	First time	Observed	Above litter		512424	6686355	
4B	McPhillips Road	14/11/2017	2317	111	19	17	50	86	0	1	Series of shallow pools	1	Female	Adult	Not gravid	70	52	0007359B0C	10 m upstream of McPhillips Road	5	Second time	Observed	On bare ground	Southern Bank			
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	Light nuptials	71	37.5	735BC4a	115m - US	1	First time	Observed	Above litter		513086	6686332	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Female	Adult	Not gravid	69	27	735B001	120m - US	1	First time	Observed	Above litter		513074	6686323	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Female	Adult	Not gravid	92	81	735A516	150m - US	1	First time	Observed	Above litter		513078	6686314	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	dark brown	84	64	735C3E4	170m - US	4	First time	Observed	Above litter		513091	6686298	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	dark brown	80	55	735AA6B	180m - US	5	First time	Observed	Above litter		513107	6686293	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	pale brown	82	55	735C3A2	210m - US	6	First time	Observed	Above litter		513111	6686294	
4B	McPhillips Road	8/02/2014	20:15	22:45	21	19	0	90	0	0	shallow, some stagnant pools	7	Male	Adult	pale brown	75	44	7354D0A	210m - US	4	First time	Observed	Above litter		513111	6686304	

Table A2. Summary of Wallum Sedge Frog surveys during the 2017/18 monitoring season.

18th – 19th January 2018											30th – 31st May 2018										
	Count 1	Count 1	Count 1	Count 1	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	Count 2	Count 2	Count 2	Count 2	Water Depth	Air Temp	Humidity	Rainfall	Cloud Cover	pH	
BACI Site	Adults	Sub Adults	Juveniles	Tadpoles							Adults	Sub Adults	Juveniles	Tadpoles							Comments
1A	2	0	0	0	0	25	75	1	0	nr	3	1	0	0	210	14	81	0	25	6.2	Most of construction works packed up. Monitoring star pickets removed
1B	1	0	0	0	0	24	77	1	0	nr	1	0	1	0	120	14	80	0	25	4.9	Site continues to provide consistently low numbers of frogs
2A	0	0	0	0	0	25	75	1	0	nr	0	0	0	0	90	15	79	0	30	5.1	Dries too quickly to enable sufficient monitoring.
2B	11	2	0	0	0	25	75	1	0	nr	15	8	3	0	290	15	80	0	30	4.8	Occasional calls during summer survey when site was dry again like the year before.
3A	0	0	0	0	0	24	80	1	0	nr	0	0	0	0	180	14	87	0	25	5.4	Site prone to drying out rapidly and periodic mowing
3B	0	0	0	0	0	24	78	1	0	nr	0	0	0	0	240	15	81	0	25	5.3	Site dry in summer survey but water in second autumn winter survey but still no frogs
4A	1	0	0	0	0	25	74	1	20	nr	3	0	1	0	350	15	81	0	0	6.5	Site maintaining a higher pH than pre construction surveys
4B	0	0	0	0	0	25	76	1	20	nr	2	0	0	0	110	15	81	0	0	5.9	Site dries out rapidly making it difficult to monitor
5A	0	0	0	0	0	27	67	0	25	nr	1	0	0	0	100	14	91	0	0	4.6	Site typically seasonally inundated but dries within weeks to months depending on groundwater levels
5B	8	3	0	0	0	27	70	0	25	nr	19	5	1	0	350	14	91	0	0	4.4	Seems to be a resilent site and form part of core or source population for the nearby impact site.

Table A3. Summary of Green-thighed Frog surveys during the 2018/19 monitoring season.

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
Compensatory Breeding Pond - Redbank Creek	5600	Redbank Creek	E:516564 N:6680284	17.12.2018	2000-2020	23	88	1	1	100	0	0	16.01.2019	30	0	0	0	No	40 mm of water in ponds and some metamorph Broad-palmed Frogs found.
1A	11800	Dirty Creek Range / Falconers	E:503224 N:6685035	17.12.2018	2117-2137	23	88	1	1	100	0	0	16.01.2019	30	0	0	0	No	Pond 2 contained 50 mm of water with Litoria latopalmata tadpoles. Some Crinia and Litorisa latopalmata found around this same pond. Remaining ponds were dry.
1A - Compensatory Breeding Pond - Dirty Creek Range (Falconers)	11800	Dirty Creek Range / Falconers	E:513172 N:6685262	17.12.2018	2117-2137	23	88	1	1	100	0	0	16.01.2019	30	0	0	0	No	Pond 2 contained 50 mm of water with Litoria latopalmata tadpoles. Some Crinia and Litorisa latopalmata found around this same pond. Remaining ponds were dry.
1A - Frog Fencing	11750-11880	Dirty Creek Range / Falconers	E:513190 N:6685262	17.12.2018	2117-2137	23	88	1	1	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing installed although a number of potential breaches (defects identified)
1B - Old (As per TFMP RMS 2015)	23000	Wells Crossing Beside Road	E:506185 N:6692721	18.12.2018	2050-2105	22	88	1	1	95	0	0	16.01.2019	30	0	0	0	No	All areas were dry. An impact site.
2A	19100	Halfway Creek	E:507641 N:6689299	17.12.2018	2200-2221	23	88	1	1	100	0	0	16.01.2019	30	0	0	0	No	All ponds were dry
2A Compensatory Breeding Pond	19000	Halfway Creek	E:507644 N:6689255	17.12.2018	2200-2221	23	88	1	1	100	0	0	16.01.2019	30	0	0	0	No	All ponds were dry
2A - Frog Fencing	18900-19300	Halfway Creek	E:507644 N:6689255	17.12.2018	2200-2221	23	88	1	1	100	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing remains partially effective with frogs calling from both sides of the fence. Observations of frogs around the fence suggest it is functional.
2B	23000	Yuraygir SRA	E:508694 N:6693816	17.12.2018	0435-0455	20	85	0	1	80	0	0	16.01.2019	30	0	0	0	No	Whole pond area and smaller outer drains were dry
3A	25800	Bald Knob Tick Gate Road	E:505801 N:6694708	18.12.2018	2232-2252	23	88	1	1	100	4	7	16.01.2019	30	0	0	0	No	Pond 3 contained 75 mm of water with no tadpoles nor juveniles. Remaining four ponds were dry. The adjacent borrow pit where several males were observed and heard calling remained at 550 mm deep.
3B	30000	Glenugie West	E:501553 N:6699052	19.12.2019	2110-2130	24	77	0	1	70	0	2	16.01.2019	29	0	0	0	No	All suitable breeding sites were dry.
4A	26200	Glenugie Heavy Vehicle Checking Station South	E:505127 N:6696150	18.12.2018	2301-2322	21	100	0	1	90	0	0	16.01.2019	30	0	0	0	No	Table drain areas were dry.
4A - Frog Fencing	26100-26250	Glenugie Heavy Vehicle Checking Station South	E:505167 N:6696111	18.12.2018	2301-2322	21	100	0	1	90	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing installed, however, there are some potential breach points but overall functionality is present.
4B	35000	Glenugie East	E:506326 N:6703965	18.12.2018	0310-0329	20	90	0	0	70	4	7	16.01.2019	30	0	0	0	Yes	All depression and inundation areas were dry.
5A	28000	Franklins Road	E:505038 N:6697387	18.12.2018	2324-2349	21	100	0	1	100	4	1	16.01.2019	30	0	0	0	No	All of the natural pond areas were dry.
5A - Frog Fencing	27900-28050	Eastern side Franklins Road	E:505014 N:6697324	18.12.2018	2324-2349	21	100	0	1	100	4	1	10.02.2018	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fencing appear functional based on Stage 1 sampling with majority of frogs were found on the vegetated side of the fence.
5B	37000	Stokers Road Bom Bom State Forest	E:498275 N:6707681	19.12.2018	0224-0244	21	90	0	1	65	4	6	16.01.2019	29	0	0	0	No	Some wheel rut areas contained 100 mm of water whilst remaining areas were dry.

BACI Site	Adjacent Chainage	Site Name	Easting Northing	Stage 1 Survey Date	Time (24hr)	AT °C	Hum %	Wind	Rain	CC	No. Calling Males (chorusing intensity)	No. Frogs Spotlighted	Stage 2 Survey Date	Days After Stage 1 Survey	No. Sub Adults	No. Juv	No. Tads	Breeding Confirmed	Comments
6A	35200	Pheasant Creek	E:502672 N:6704172	no data - site restrictions still in place									no data - site restrictions still in place						No access permitted at this time
6B	38000	Airport Road	E:501766 N:6706969	18.12.2019	2357-0017	20	98	0	1	80	15	14	16.01.2019	30	0	0	0	Yes	Depression area adjacent to the road was dry
7A	38000	Old Six Mile Lane	E:503837 N:6706546	19.12.2018	0023-0042	23	98	0	1	80	6	7	16.01.2019	29	0	0	0	No	All suitable breeding sites were dry.
7B	35000	Glenugie East	E:505733 N:6703338	19.12.2018	0346-0409	20	89	0	1	70	9	10	16.01.2019	29	0	0	0	No	All suitable breeding sites were dry.
8A	64700	Tyndale Crown Reserve	E:513362 N:6727361	19.12.2018	0102-0122	22	90	0	1	100	2	0	16.01.2019	29	0	0	0	No	Small residual pool from borrow pit area contained 150 mm of water but no tadpoles. Remaining areas were dry.
8A - Frog Fencing	64600-64800	Tyndale Crown Reserve	E:513362 N:6727361	19.12.2018	0102-0122	22	90	0	1	100	2	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fence generally in good order, however, the access road provides obviously breach point and was historically a focal point for frogs to congregate in the drains
8B	57500	Pine Brush State Forest	E:517300 N:6719708	19.12.2018	0134-0155	22	90	0	1	50	0	0	16.01.2019	29	0	0	0	No	All suitable breeding sites were dry.
9A	102500	JackyBulbin	E:520731 N:6758742	03.04.2019	2005-2045	20	95	0	2	100	3	2	15.05.2019	42	0	0	0	No	Some flooded depression area with residual water of <50 mm.
9A – Frog Fencing	102100 - 102600	JackyBulbin	E:520731 N:6758742	03.04.2019	2005-2045	20	95	0	2	100	3	2	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fence in generally good order although some obvious breach points.
9B	111500	Tabbimobile East	E:525262 N:6767265	03.04.2019	2100-2120	20	90	0	1	100	3	4	15.05.2019	42	0	0	0	No	Main borrow pit area to the north contained 150 mm of water but no GtF tads were recorded.
10A	118500	Tabbimoble North	E:527238 N:6772864	04.04.2019	2250-2310	19	88	0	1	80	0	0	15.05.2019	42	0	0	0	No	Old breeding pond removed by construction. Sampled neighbouring depressions towards gully that contained small residual pools.
10A – Frog Fencing	118500	Tabbimoble North	E:527238 N:6772864	04.04.2019	2250-2330	19	88	0	1	80	0	0	not relevant	not relevant	not relevant	not relevant	not relevant	not relevant	Frog fence in generally good order although some obvious breach points.
10B	114000	Glencoe Road	E:524143 N:6769665	04.04.2019	2155-2215	20	85	0	1	90	1	1	15.05.2019	42	0	0	0	No	Some table drains with small residual pools to 150 mm deep but no GtF tadpoles.

Table A4. Rainfall data (New Italy Station 58097) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 8-10 during the 2018/19 monitoring season.

2019	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1st	0	0	0	0	0	0	0	2.6
2nd	0	0	0	0	2.2	3.0	4.0	7.2
3rd	0	0	0	0	0	5.8	62.0	0
4th	0	0	0	0	0	0.4	0	0
5th	3.0	0	0	0	0	0	0	0
6th	1.2	1.0	0.6	0	2.4	0	0	0
7th	4.6	0	0	0	5.5	0	0	0
8th	3.4	0	0	0	0.4	47.0	0	0
9th	1.2	0	0.4	0	0	1.6	0	0
10th	0	0	0	0	0	1.4	4.6	0
11th	47.8	6.6	0	0	0	0	1.6	0
12th	34.0	0	0	0	0	0	2.6	0
13th	8.6	0	0	0	0	0	3.6	3.0
14th	37.2	0	2.6	0	0	0	1.2	0
15th	34.6	0.8	0	0	0	0	1.8	1.8
16th	19.8	6.6	0	0	0	26.2	3.6	1.0
17th	22.6	0.8	10.4	0	0	4.6	3.0	8.2
18th	0.6	31.6	31.0	0	0	5.6	5.6	1.4
19th	0	4.0	0	0	0	1.2	7.2	3.6
20th	0	0	4.6	0	0	0	25.4	1.0
21st	0	0	18.0	0	0	0	6.4	0
22nd	4.2	32.2	8.2	0	20.0	0	0	0
23rd	0	0	6.8	0	3.5	3.4	2.6	0
24th	0	0	0.6	0	7.0	0	0	0
25th	0	0	0	0	4.6	0	10.0	0
26th	1.0	0	0	0	2.6	0	2.0	2.0
27th	0	0	0	0	0.2	19.0	0	0
28th	0	0	0	0	0	1.6	0	0
29th	0	22.0	0	0		0	0	0
30th	1.6		0	0		1.6	0	0
31st			0	0		3.6		0
Highest Daily	47.8	32.2	31.0	0.0	20.0	47.0	62.0	8.2
Monthly Total	225.4	105.6	83.2	0.0	48.4	126.0	147.2	31.8

Table A5. Rainfall data (Grafton Airport - Station 58161) with survey dates (shaded red) for Green-thighed Frog surveys at Sites 1-7 during the 2018/19 monitoring season.

2018/2019	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1st	0	0	0	0	0	0.2	0	3.0
2nd	0	0	0	0	4.6	0.4	1.8	0.8
3rd	0	0	0	0	0.2	4.8	4.0	0
4th	0	0	0	0	0	1.2	0.2	0.4
5th	11.6	0	3.2	0	0	0	0	2.2
6th	1.6	0	0	0	3.8	0	4.6	0
7th	9.6	0.2	0	0	0.8	0	0.2	0
8th	0.2	4.4	0.2	0	0.4	2.6	0	0
9th	0.4	0.6	0	0	0	0.2	0	0.2
10th	0	0	0	0	1.0	0.2	0	0
11th	10.8	1.0	0	0	0.2	1.0	0	0
12th	7.4	0	5.8	0	0	0.4	5.6	0
13th	7.8	0	5.6	0	0	0	0.2	2.4
14th	12.6	0	17.8	0	0.2	0	0.2	0.8
15th	38.8	0	0	0	0	0.2	0	0
16th	12.8	0	0	0	0	5.2	0.2	11.2
17th	14.8	0	131.2	0	0	2.2	0.6	8.2
18th	1.6	11.2	0	0	0	1.0	0	0
19th	0	0.2	0	0	0	0.2	1.2	0.2
20th	0	0	9.6	0	2.2	0.4	18.2	0
21st	6.0	0	25.8	0	3.2	0	0.2	0.2
22nd	7.6	5.4	3.8	0	2.4	0	0.2	0
23rd	0	0.2	0	2.2	0.2	26.0	3.8	0
24th	0	0	0	0.2	0.8	0.2	10.0	0.2
25th	0.2	0	0	0	1.8	0.2	0	0
26th	0	0	0	0	8.8	0	0	0
27th	0	0	0	0	0.4	15.0	0.2	0.2
28th	0	0	0	0	0.4	0.2	0	0
29th	0.2	0.8	0	0		0.2	0	0
30th	1.0	0	0	0		0.4	0	0
31st	0		0	0		14.6		0
Highest Daily	**38.8**	**11.2**	**131.2**	**2.2**	**8.8**	**26.0**	**18.2**	**11.2**
Monthly Total	**145.0**	**24.0**	**203.0**	**2.4**	**31.4**	**77.0**	**51.4**	**30.0**